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THE FEEDING OF INFANTS

THE NATURAL AND ARTIFICIAL METHODS OF FEEDING INFANTS AND YOUNG CHILDREN

BY

EDMUND CAUTLEY

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SECOND EDITION

"They look up with their pale and sunken faces
And their looks are sad to see."
ELIZABETH BARRETT BROWNING

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J. & A. CHURCHILL

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PREFACE TO SECOND EDITION.

SEVERAL modifications in this work have become necessary since the first edition was published.

During the interval there has been ample opportunity to investigate and estimate the advantages of the comparatively recent system of percentage feeding. The advances along this line have been chemical rather than clinical, and the attempt to treat the infant's stomach as a test-tube has not proved altogether successful. The American physicians, to whom must be given the credit of introducing this system, have elaborated it to such an extent that the complicated formulæ evolved are alarming, unwieldy and unnecessary.

Further experience of the various processes of sterilisation have led to some modification of the views expressed as to its necessity and the effect on the nutritive value of the milk.

The question of the transmission of tuberculosis by infected milk is more fully considered and, though in the main agreement is expressed with the views of Professor Koch, it is still regarded as by no means definitely settled.

The chapter on the feeding and management of premature infants has been considerably amplified.

Although the feeding of infants is free from the taint of empiricism, and every year rests on a more scientific basis, it still remains largely an art which gives ample scope for judgment and resource. The great secret of success consists in careful observation and minute attention to detail.

EDMUND CAUTLEY

15 Upper Brook Street,
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June 1903.

PREFACE TO FIRST EDITION.

This work represents an attempt to give a description of the present state of our knowledge of the feeding of infants and young children, sufficiently concise for the busy medical practitioner and the overworked student, and yet adequate in its outline of a subject which has made such extensive progress within recent years and is of such vital importance to the health and well-being of the nation.

The child's future health and strength commonly depend upon the way it has been fed during the first few years of life.

So much better understood at the present day are the chemical processes taking place in digestion, and the composition of the various available foods, that our methods of feeding may fairly claim to have emerged from the region of empiricism and to rest on a scientific basis.

Although physiological chemistry plays a very large part in the consideration of the subject, due attention is devoted to the clinical factors concerned in successful feeding and to the idiosyncrasies of the particular infant. No hard-and-fast rules are insisted on as suitable for every case, and the practitioner has plenty

of scope for the exercise of his individual judgment, even if he accepts fully the views here put forward.

Numerous authorities are referred to and quoted. To these the writer is deeply indebted; more especially to Dr. Rotch, of Harvard University, and Mr. Leeds, the American Chemist. The writer is glad to find himself so closely in accord with the views of the former, supported as they are by clinical experience, while the analyses by the latter are of such value that free use has been made of them. The American Pædiatric Physicians can justly claim to have advanced far beyond their English *confrères* in the development of a scientific knowledge of this branch of medicine, and their work deserves the fullest recognition.

My thanks are due to Mr. Hawksley for the illustrations of his various kinds of apparatus used in the sterilisation of milk.

EDMUND CAUTLEY.

15 Upper Brook Street,
London, W.
December 1896.

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WEIGHTS.

English System.

1 grain	=	0·0648 gramme
1 drachm = 60 grains	=	3·8880 grammes
1 ounce = 437·5 grains . . .	=	28·3495 „
1 lb. = 16 oz. = 7000 grains . .	=	453·5925 „

Metric System.

1 milligramme = 0·001 gramme .	=	0·015432 grain
1 centigramme = 0·01 „ . .	=	0·154323 „
1 decigramme = 0·1 „ . .	=	1·543235 grains
1 gramme	=	15·43235 „
1 decagramme = 10 grammes . .	=	154·3235 „
1 hectagramme = 100 „ . .	=	1543·235 „
1 kilogramme = 1000 „ . .	=	15432·35 „
	=	2 lbs. 3 oz. 119·8 „

MEASURES OF LENGTH.

English System.

1 inch	=	25·4 millimetres
1 foot	=	304·8 „
1 yard	=	914·4 „

Metric System.

1 millimetre = 0·001 metre . . .	=	0·03937 inch
1 centimetre = 0·01 „ . . .	=	0·3937 „
1 decimetre = 0·1 „ . . .	=	3·937 inches
1 metre	=	39·37 „

MEASURES OF CAPACITY.

English System.

1 minim	=	0·059 cubic centimetres
1 fluid drachm = 60 minims .	=	3·549 „ „
1 fluid ounce = 8 fluid drachms .	=	28·396 „ „
1 pint = 20 fluid ounces . .	=	567·936 „ „
1 gallon = 8 pints . . .	=	4·54837 litres

Metric System.

1 litre = 1000 cubic centimetres and each cubic centimetre is the volume of 1 gramme of distilled water at 4° C.

1 cubic centimetre (1 c.c.) = 16·931 minims.

1 litre = 35·2154 fluid ounces = 1 pint 15 oz. 2 drs. 11 minims.

THERMOMETRIC SCALES.

To convert degrees Fahrenheit into degrees Centigrade subtract 32 and multiply by $\frac{5}{9}$, or $C. = (F. - 32)\,\frac{5}{9}$. Conversely, degrees Centigrade may be converted into degrees Fahrenheit by multiplying by $\frac{9}{5}$ and adding 32, or $F. = \frac{9}{5}\,C. + 32$.

THE FEEDING OF INFANTS.

CHAPTER I.

INTRODUCTORY.

Were an apology needed for the appearance of another publication on such a hackneyed subject as the natural and artificial methods of feeding infants and young children, sufficient excuse would be found in the mortality tables of the Registrar-General. These tables alone show that the importance of the subject is very much greater than is commonly realised by the medical profession and the public.

In spite of the advances made during the last ten years, the diet and management of infants are still much too freely entrusted, without competent supervision, to ignorant mothers and prejudiced nurses.

Yet the health of the infants depends usually on the way they are fed during the early stages of existence, and on the health of the children rests the welfare of the nation.

It is astonishing how largely the theory and the practice of this branch of medicine are neglected by the teachers at the great metropolitan schools. Many a student leaves his hospital, a fully qualified

medical practitioner, ignorant of the capacity of the infant's stomach and the frequency with which it should be put to the breast. Even more ignorance is displayed about the causes which lead to changes in the composition of human or cow's milk, and of the symptoms which indicate the necessity for immediate weaning on the one hand or the prolongation of suckling on the other.

In knowledge of the different substitutes for human milk, and of the various artificial foods so widely advertised, the newly qualified doctor is rarely better informed than the mother of two or three children. As to the chemical composition and the nutrient value of any such food a still more profound ignorance commonly prevails. The manufacturer's advertisements of fine fat children, apparently healthy, and the composition of the food as stated on the label, are usually all the data thought requisite to form an opinion as to its value.

And yet more than half the patients the doctor has to treat are infants or young children, and more than half their ailments are due to disorders dependent on the food supply.

The physiological teaching during the early stages of a medical curriculum takes some account of the composition of foods and the changes which they undergo as the result of the action of the digestive ferments. This teaching is to a large extent laid on one side, pigeon-holed for future use or forgetfulness, by the student when he enters upon the study of medicine, and his teachers exceptionally refer to it as the basis on which their treatment depends.

At a general hospital infants are often not

admitted, and even when taken in rarely receive such minute clinical care and attention as, for the sake of the student, ought to be bestowed upon them. Often they are not suitable cases for clinical teaching, for by reason of the size of the child and its fretfulness on examination under the gaze of many strange and sometimes unsympathetic faces, it is impossible for more than one or, at the most, two observers to make a thorough clinical examination. Babies are not satisfactory subjects for the demonstration of physical signs to the beginner. The physical signs in infancy, due to disease of the lungs for instance, are often anomalous and the student is better occupied in acquiring simpler and more straightforward knowledge.

But all these students go out into the world, when qualified as medical men, prepared to treat every ailment of the infant which comes under their notice.

In the Out-Patient Department of a Children's Hospital it is especially common to meet with cases of dyspepsia, colic, diarrhœa, and often profound marasmus mainly, if not entirely, dependent on the wide-spread ignorance of this subject. Often it is the mother who is solely to blame for the condition of her child, or some kind friend, such as the landlady or "the woman next door," who has taken upon herself the responsibility of recommending the addition of a patent food to the diet of the infant, even a few days after birth, at a time indeed when it is quite incapable of digesting such a food.

The medical literature on the subject is peculiarly copious. Except in works devoted to the Diseases of Children, or monographs on digestive disorders,

or in the scattered articles appearing from time to time in the medical journals, it is much too often published in a form devised partly for the medical practitioner, partly for the use of the nursing mother. Much of such work is spoilt by imperfections in the physiological groundwork, and even physiological errors.

Infant Mortality.—The following table, from the Reports of the Registrar-General for the ten years 1891-1900, shows clearly how immense is the mortality among infants under one year of age. Of course a large number of such deaths are inevitable, but many are preventable.

TABLE I.

Mortality Table for England and Wales, 1891–1900.

Year.	Total births.	Total deaths.	Deaths under one year.	Proportion to 1000 births.	Deaths from diarrhœa.	
					Total No.	Under one year.
1891	914,157	587,925	135,801	149	13,962	9,200
1892	897,957	559,684	132,463	148	15,336	10,487
1893	914,572	569,958	145,061	159	29,721	20,722
1894	890,289	498,827	121,799	137	10,763	7,360
1895	922,291	568,997	148,093	161	27,392	19,577
1896	915,309	526,727	135,013	148	17,388	13,057
1897	921,693	541,487	143,589	156	27,051	20,228
1898	923,265	552,141	148,013	160	30,096	22,701
1899	928,646	581,799	150,975	163	30,971	23,669
1900	927,062	587,830	142,912	154	23,463	17,639
Total	9,155,241	5,575,375	1,403,719	—	226,143	164,640
Average	915,524	557,537	140,371	153	22,614	16,464

If the figures for a large number of years are taken it is found that the infantile mortality has varied between a minimum of 130 per thousand births in 1881 and a maximum of 164 in 1847. Comparing these figures with those in Table I, it does not appear that any great advance has been made in the reduction of the infant mortality during the last fifty years. The number of deaths from diarrhœa under one year is enormous when compared with the total number of deaths from this cause at all ages during the year. More than two-thirds of the total number of deaths due to diarrhœal disease occur in infants under one year of age. It is noticeable that the number varies considerably in different years, and that the infantile mortality varies very closely with the number of deaths from this cause. In the years 1898 and 1899 the usual mortality from diarrhœa was exaggerated; this was no doubt due largely to a prolonged period of very hot weather.

In large towns the infantile mortality is even greater. During the ten years 1891–1900 the average proportion of deaths under one year to 1000 births in London was 160. Here again the mortality from diarrhœa was chiefly in infants under one year, averaging 2545 out of 3431.

A higher percentage of the children born in a large town die from diarrhœal affections than in the country as a whole; and a higher percentage of the deaths from diarrhœal affections in a large town occur in infants under one year of age.

If a comparison be made between rural counties such as Rutlandshire, Dorsetshire, and Wiltshire, and mining and manufacturing counties, namely,

Durham, Lancashire, Warwickshire, Staffordshire, and Nottinghamshire, it is found that the infantile mortality is very considerably higher in the industrial districts. In Rutlandshire it was only 79 per 1000 in 1900. In the industrial counties it ranged from 175 to 180. It was even higher in certain selected towns, the worst being Blackburn, Leicester, and Preston.

Similar results obtain throughout the country. The more rural the district the lower is the infantile mortality. The more industrial the town the greater is the infantile mortality. This is due to one or more of three causes.

1. Insufficiency of fresh air in the towns and bad hygienic surroundings.

2. Deficient or contaminated milk supply for bottle-fed infants.

3. The lack of breast milk. So many mothers wean their children, partly or entirely, in order to get back to the mills, &c.

The exact effect of women working in factories is doubtful, and statistics are of little value unless the number of domestic servants is taken into consideration. In some of the industrial centres there are few women in service. Consequently the statement that the infantile mortality varies according to the number of married women employed is not strictly accurate. To a certain extent the children of industrious mothers are healthier at birth and have better home surroundings than those whose mothers are idle and irregular in their habits. It is illegal for the mother to return to work until one month after her confinement, and during this period the infant may be breast-fed. Were this interval extended to

three months and the child suckled during this time there would be a considerable reduction in the infantile mortality, for the most dangerous period for artificial feeding would be past.

The number of deaths from diarrhœal affections at this early age is a fair indication of the mortality from unsuitable feeding. Of course it does not indicate nearly the whole mortality due directly or indirectly to this cause. For instance, we find in the Report for 1900 as causes of death in England and Wales under one year of age, thrush 284; starvation or want of breast milk 459; scurvy 21; rickets 508; dentition 2220; enteritis 3211; gastro-enteritis 5226; tabes mesenterica 2886; convulsions 16,022; and many other causes more or less directly connected with the mode of feeding. In this year alone no less than 17,639 infants under one year died from diarrhœal affections, and only 3330 children between the ages of one and five years. Of the latter, 2851 died during the second year of life.

Debility, atrophy, and inanition accounted for 19,075 deaths under one year, 887 between one and two years, and only 182 between two and five years of age.

Other very common causes of death are bronchitis and pneumonia. Of these, too, the greater part is due to a debilitated condition of the body or to rickets, dependent mainly on the food-supply.

In connection with this subject the subjoined table of results, obtained by Dr. Cameron on inquiry into a series of 153 deaths of children under one year, registered in the Borough of Leeds as due to diarrhœa during six weeks preceding September 30,

1893, is both of interest and value. The number of cases is insufficient for very reliable conclusions, but the main points are well illustrated. Eighty per cent. of the cases occurred in houses with no through draught. The table shows very clearly: (1) That the mortality among those brought up at the breast is very small compared with those not so reared; (2) That the mortality is largest among those brought up on the bottle; and (3) That the mortality is much larger during the first six months of life than during the second; a proportion of 96 to 57 cases, or 63 to 37 per cent.

TABLE II.

Deaths due to Diarrhœa and the Mode of Feeding (CAMERON).

Age in months.	Cases investigated.	Percentage of the 153.	Percentage of those dying fed			
			On breast only.	On breast partially.	Not on breast at all.	By bottle.
0–3	41	27	24	20	56	71
3–6	55	36	16	13	71	76
6–9	34	22	3	9	88	91
9–12	23	15	30	17	52	61
	153	100	18	14	68	76

So closely is the infantile mortality connected with the manner of feeding that any marked difference in the death-rate of children under one year will almost certainly be due to some difference in the method adopted. Thus in some countries, of which we have reliable statistics, the mortality ranges between a minimum of 8·5–10·5 in the Faroe Islands and

Norway, and a maximum of over 30 per cent. in Iceland, Bavaria, Austria, Hungary and Spain. In the former places the infants are invariably reared at the breast, while in the latter they are almost as constantly brought up on farinaceous food. The mortality among the bottle-fed in Spain is given by Dr. Criado y Aguilar, of Madrid (1902), as 67–80 per cent. Out of four hundred deaths of children from summer diarrhœa that came under the observation of Minert in Bavaria, 96 per cent. were fed artificially. During times of great distress, as during the Siege of Paris and the Lancashire cotton famine, the infant mortality is largely reduced, while the adult mortality is increased. Clearly the explanation lies in the fact that at such times the mothers are compelled to suckle their babes, and the great source of fatalities is thereby abolished.

The mortality from diarrhœa is usually greatest during the summer, and is often attributed to the excessive heat. Against this view it may be urged that a high atmospheric temperature during the second quarter of the year does not give rise to the typical epidemic. Sometimes it is attributed to fruit-eating but, seeing that the mortality is chiefly among infants under one year of age, this is not a plausible explanation. Children of that age are not usually fed upon fruit, and the mortality is greater in the towns than in the country districts where fruit can be more easily obtained. On the other hand it may be urged that the fruit reaching the consumer in the towns is much more liable to be over-ripe or fermented.

That a high external temperature has a marked effect in increasing the mortality from this cause is

very evident on referring to the figures for 1893, 1898 and 1899, in the first table. Almost certainly the result is due to the rapidity with which various fermentations occur in milk under such conditions, leading to the development of poisonous products in the milk before or after it reaches the consumer, or to the rapid multiplication of deleterious micro-organisms in this fluid. Other articles of food are liable to similar injurious changes.

Ballard made a prolonged and careful investigation into the causation of infantile diarrhœa, and deduced the following conclusions :—

1. Infants in all conditions of life fed solely from the breast are remarkably exempt from fatal diarrhœa.

2. Infants fed in any way with artificial food, to the exclusion of breast milk, suffer the most heavily.

3. Infants fed partially on the breast and partially on artificial food occupy an intermediate position.

4. The " bottle " is the most dangerous method of artificial feeding. In other words, the excessive mortality among infants from diarrhœa is due to the methods of feeding, that is, to artificial food and the mode of preparation and administration.

The food may be in itself sound and wholesome and yet dangerous because unsuited to the digestive capacity of the child. Or it may be perfectly suited to the child's digestion and requirements, and yet dangerous from having been stored in dark, ill-ventilated places, exposed to infection from stinking soil, walls, or drains. Or it may happen that the food is wholesome and suited to the digestive

capacity of the particular infant, while the evil result is due to dirty feeding-bottles, rubber tubes or nipples, or to over-feeding and irregularity in feeding. In artificial feeding there is less liability to diarrhœa and other forms of digestive disturbance when the food is given from a clean cup in a clean teaspoon than when a bottle of any description is used.

CHAPTER II.

THE MOTHER OF THE CHILD.

CERTAIN statements are so often made and are based on such a large amount of facts and clinical evidence that they may be almost regarded as axioms and may be expressed in this form.

Axiom 1. Early mortality depends largely on diseases of the digestive organs.

Axiom 2. Every healthy mother contributes to derangements of digestion in her child by refusing to nurse it.

Axiom 3. Normal alimentation is especially important during the first few months of life, and for this period at any rate breast-feeding must be insisted on.

Curious views were held in former days on the subject of human milk. In the seventeenth century Van Helmont, a chemist, maintained that human milk was very bad because it led to inborn propensities being transmitted. He recommended a diet of bread boiled in beer or honey. Even at the beginning of the nineteenth century Brouget, a French physician, stated that mother's milk bred immorality and hereditary disease.

Now, and for many years, human milk has so clearly proved the proper diet for an infant that breast-feeding must be regarded as a duty as well as

a pleasure. Nursing also has other advantages. It causes more complete involution of the uterus. It sometimes lessens the chance of impregnation at too short intervals. It may benefit a delicate mother through the increased diet, the manner of life, and the occupation of the mind. It may increase the affection of the mother for the child, a result not to be despised in a class accustomed to leave the care and management of the children to nurses and servants.

Although it is admitted universally that the best method of rearing infants is to bring them up at breast, it is often found that infants so reared do not thrive well, and by comparison with others brought up on the bottle appear small and ill-nourished. Such infants are more irritable, restless and sleepless, and require more care than ordinary babies. Some may be quiet, not crying, and yet not thriving. It might at first sight be thought that the cause of this difference is in the method of feeding adopted, and that artificial feeding is better than breast-feeding. In truth the fault lies not in the method, but in the subject. It must clearly be understood that not every mother is fitted to suckle her child. Unfitness for the due performance of this function may depend upon one or more of several causes, such as various conditions of ill-health or malnutrition, affections of the breast or nipples, insufficient supply of milk, mode of life, mental and moral characteristics.

Some of these conditions can be remedied if the mother wishes to nurse her child and is willing to devote her life, for the time being, to this duty. But if the mother is more anxious to devote her life to her own pleasures and amusements, and regards the

infant as a secondary consideration, the case is a hopeless one and partial weaning will have to be adopted as the lesser evil.

Economic conditions may prevent the mother suckling her child. She may have to go out to work to earn money for herself or others.

The Preparation of the Mother for Child-bearing.—The care of the child should begin long before birth; even from the time of conception. No doubt healthy babies have been born and will continue to be born under the most deleterious conditions affecting the mother during pregnancy. It may, however, be taken for granted that, other factors being equal, the more healthy the mother, the sounder and more healthy will be the offspring. Cases of intra-uterine rickets have been met with and, apart from such evident disease as this, infants are frequently described as delicate from their birth. Such infants are the ones so difficult to rear, and are especially liable to succumb to infantile disorders. It is an important part of the family physician's duty so to direct and modify the mode of life, the diet and various other details, as to keep the mother in the best possible health and prepare her for the duty of suckling and the due development of the functional activity of the mammary glands, an activity which should continue for a period of nine or ten months, and under certain circumstances has been maintained for as long as two and a half years.

The Diet.—During gestation the mother has to provide material for the development of her child and to maintain her own nutrition. A more generous diet than ordinarily taken is requisite for this purpose. According to Dr. W. J. Thayer, of

Brooklyn, New York, the expectant mother "early in gestation should begin to eat, at least three times a day, some form of coarse cereal food, such as Graham rye or Indian breads. These articles, being made from the *unbolted* products of the grains used, contain a much larger proportion of lime salts than the preparations of fine bolted flour of ordinary employment. The result is that the mother supplies her offspring, first through the umbilical cord and afterwards through the mammary glands, with a pabulum containing essential elements for the nutrition of a very important set of organs, viz., the teeth. The teeth commence to develop about the sixth week of intra-uterine life, and their subsequent importance for purposes of digestion, articulation, and preservation of the contour of the face, cannot be over-estimated." During gestation the mother's teeth frequently suffer, and it has been argued that the salts are abstracted from them for the supply of the infant or, more probably, that the salts necessary to maintain their nutrition are not duly supplied to them, being diverted to the developing child. It is exceedingly doubtful whether these foods possess the value ascribed to them by Thayer. Such a value is based largely upon the assumption that the coarser cereal foods are equally well digested and assimilated as the finer ones. The assumption is not supported by facts, for the coarser the food the more is wasted passing away by the bowel. Chemically there is very little difference between the percentage of gluten in the whole meal and in fine wheat flour, and though the former contains much more cerealin, a nitrogenous ferment present in the outer coats of the grains, this excess of cerealin is of doubtful advantage.

Weight for weight the finer the flour the more easily is it digested and utilised, and the better the nutrition. Any advantage the coarse cereal foods, such as oatmeal and whole meal bread, possess, is due to the irritation of the intestinal mucous membrane giving rise to increased peristalsis, thus counteracting the tendency to constipation, so often troublesome during pregnancy. The chemical structure of the mother is essentially the same as that of the child, and food which will maintain the nutrition of the mother will, if slightly increased in amount, suffice for the needs of the developing infant. Milk, as will be shown below, contains all the elements necessary for the nutrition of the child. A little more bread, meat, and milk are therefore all that are necessary, in the shape of extra food, for the mother during gestation. Fruits, raw or cooked, green vegetables and salads, are all useful as indicated in the next paragraph. Stimulants are not essential and are not contra-indicated. Drunken habits in the mother are decidedly injurious to the future child. The injury to the nervous elements may be transmitted and appear as mental or moral imbecility, dipsomania, or a marked neurotic disposition.

The Bowels.—Sufficient has been said in the above paragraph to indicate the value of coarse cereal food-stuffs in preventing constipation. A modification of the diet in this direction is generally sufficient to meet the ordinary requirements of pregnancy. Some women are normally constipated, partly from habit, partly from the nature of the food they live upon. Further modification of the diet may remedy the trouble—*e.g.*, taking plenty of green vegetables, prunes, figs, and marmalade. Drugs may

be required for the more severe cases, and of these the mild purgatives, such as aloes, cascara sagrada, liquorice powder, or some one or other of the mineral waters—such as Hunyadi Janos, Condal or Friedreichsall—are the most satisfactory. Though advisable for the comfort and well-being of the mother that the bowels should act daily it is not essential. Many mothers are perfectly comfortable and contented if they are relieved every three or four days.

Exercise.—To a certain extent inability to take exercise is one of the causes of constipation. Some women during gestation have a regular daily action of the bowels, provided they are able to take daily walking exercise. After conception, if it is desired to avoid the least risk of miscarriage, no violent exercise, such as mangling, lifting heavy weights, cycling, riding, or dancing, should be indulged in. Rapid driving or riding over a rough road is dangerous and may induce separation of the placenta. A moderate walk at a medium pace must be taken in the morning and afternoon. Exercise should stop short of fatigue and should, if possible, be taken in a public place, such as a park, where a seat can be readily obtained for a temporary rest. It is advisable, if the mother be not prevented by swelling of the legs or pain, that such exercise be continued up to the end of pregnancy. By so doing the nutrition and the activity of the muscles are maintained in a condition fit for the strain to be thrown upon them. Besides this the general health is maintained and the mother recovers more rapidly from her confinement.

According to observations by Pinard (1895), it is

very important that women should be kept at rest towards the end of pregnancy, and hard work is an evil both for the mother and the future child. He found that the average weight of infants born in a lying-in hospital, to which the mothers came for assistance usually after the first pain at least had come on, was 3010 grammes. Infants born of mothers who had been carefully nursed in a refuge for at least ten days before confinement weighed on an average 3290 grammes. A maximum average of 3366 grammes was reached by the infants of mothers who had resided for some time previously in the hospital wards; but the mothers in the latter case were relatively better off, and more of them were multiparæ. Pinard also found that preliminary rest had a particularly good influence on the duration of labour. Out of a thousand women who worked until labour began 482 were delivered on or after the 280th day of gestation. Out of a thousand women who had rested previously 660 were delivered on or after the 280th day.

No doubt good food and rest for women who are about to be confined are distinct advantages, and the favourable results will be most in evidence among the class of women who come to the lying-in charities. The relief from the worries and troubles of their previous surroundings must be considerable, and all the advantage gained should not be put down merely to the physical rest.

Among the active women of the lower classes a week to a fortnight is generally as much as they allow themselves to recover from the fatigues of labour, a very marked contrast to the prolonged period requisite for the delicately nurtured woman

of the higher classes, who has not, perhaps, put a foot to the ground during the last three months of her pregnancy, and whose only means of going about has been an open carriage or a bath-chair.

Mental Excitement.—This should be avoided. All strong emotions must be guarded against or controlled. It is a popular belief that mental impressions may have a direct effect on the development of the child and give rise to deformities. Many such cases are recorded, and are equally difficult of proof or disproof. Every one can call to mind instances. I know one man who ascribes a birthmark on the right buttock to the fact that his mother was thrown from a pony phaeton during her pregnancy, and had a bruise in that situation. It is certainly advisable that pregnant women should avoid the sight of horrors or deformities. The same idea dates back to the time of Jacob (Genesis xxx.). On the other hand it may be pointed out that there are no nerve fibres in the umbilical cord to carry impressions. Further, it can be urged that deformities are rare, but maternal impressions are common. In many cases of deformity we can get no history of any such cause.

General Hygiene.—All the usual conditions insisted upon for an ordinary person are still more essential for the future mother. A well-ventilated room with a west or south aspect, a daily tepid sponge-bath, and the daily exercise are the most important factors in keeping the comparatively inactive woman in good health. Suitable companionship to prevent too constant thinking of the event to come, freedom from household cares and worries, and employment for the hands in making baby-

clothes, are all distinctly advantageous. A rest during the middle of the day, either on a sofa or in bed, must be insisted on during the later months. The hour for rising may depend upon the general condition, and the hour for retiring must not be later than ten o'clock. Clothing must be worn loose so as not to interfere in any way with the already impeded respiratory movements, or to exert pressure or friction on the enlarged breasts and nipples. A broad strong jean or flannel bandage may be worn, if necessary, as a support for the lower part of the abdomen.

Management of the Breasts and Nipples.—In a primipara no special care is necessary for the breasts beyond ordinary cleanliness and a loose arrangement of the clothes, to prevent undue pressure. In a multipara, especially if the breasts are large and pendulous, a moderate degree of support by a suitably arranged bandage or handkerchief will diminish the dragging sensation produced by the increasing size and weight. The skin in the folds below the breasts must be thoroughly washed night and morning, and freely dusted with some drying powder, such as Emol-Keleet or equal parts of zinc oxide and starch. The care of the nipples is of much greater importance, because of the liability to excoriation and fissures during the period of suckling. For three months before the birth of the child the nipples should be daily washed with hot water, and freely anointed with pure vaseline, lanoline or cacao-butter. If they are at all small or retracted the mother must be taught to use her finger and thumb to draw them out. Manipulation after this method, freely anointing them first, gives

them a proper size and shape, and makes the epithelial covering soft and pliable, without hardening it. All astringent or spirituous lotions should be avoided, as they harden the skin and make it much more liable to crack. Neither direct nor indirect suction should be employed. During the latter months the nipples become swollen and prominent; they must be guarded against undue pressure and friction, so as to prevent excoriation. Surrounding and covering them with an antiseptic wool, such as salicylic wool, is quite sufficient for the purpose. The recommendation of one authority that a wire tea-strainer should be worn over the nipple to prevent pressure is not worthy of adoption. If there is much overflow of milk special care must be taken to keep both the nipples and surrounding tissues clean and dry by frequently changing the antiseptic wool.

Drugs during Pregnancy.—Most drugs can be taken in moderation with impunity and sometimes with decided advantage to mother or child. Thus tonics, digestive mixtures, and mild purgatives are of value to the mother. In certain conditions a prolonged course of mercury is absolutely essential. Salicylates can be given with impunity, although it has been supposed that "white infarction" of the placenta is due to these drugs. This affection of the placenta is a cause of intra-uterine death of the fœtus, and is said to occur most commonly in women with a decidedly rheumatic history. Strong purgatives, large doses of quinine, ergot of rye, and similar drugs must be avoided.

The Nursing Mother.—Careful attention to the above details will prepare the mother for the

duties of suckling, but will not succeed in making every woman a satisfactory nursing machine. Numerous factors must be taken into consideration as more or less requisite for the formation of a perfect mother and the consequent well-being of the child. The mother should have a good constitution, a healthy environment, freedom from worry, nutritious diet, air and exercise.

Age, &c.—The most perfect mother is a woman of twenty-five to thirty-five years of age, who has already had one child and consequently has some experience in the mode of management. Several previous pregnancies, especially if in rapid succession, lower the general health and interfere with the quality of the milk. It has been stated that brunettes yield a richer milk than blondes. This is not only doubtful but, even if true, is not necessarily an advantage. An excess of proteid, and even of fat, may render the milk indigestible.

Physical Health. — A good mother should present, both on superficial and more thorough examination, all the appearances of perfect health. She should be strong, robust and well-nourished, but it is of no advantage to be fat. The appetite should be good, the teeth and digestion excellent, and the bowels open daily without the aid of medicine. She should be in the habit of taking moderate walking exercise daily, when well enough, in order to maintain her general health and to encourage the metabolism of tissue. Sleep should be regular and undisturbed. Besides all this she should be free from any evidence of past constitutional disease, more especially tuberculosis in any form, congenital or acquired syphilis, or rickets in childhood,

The Breasts and Nipples.—If the mother is a primipara the fully developed breasts are conical or pyriform in shape, not necessarily large, but firm to the touch, with well-developed prominent nipples. Such breasts neither drag, nor require support. In a multipara, on the other hand, the breasts are somewhat pendulous as the result of previous nursings. Large breasts are not necessarily more valuable for the purposes of lactation, they do not as a rule contain a proportionately large amount of glandular structure, the increased size being due to an excessive quantity of fat. A large breast of this kind diminishes little in size during suckling, whereas a well-developed gland becomes markedly smaller and less tense, and enlarges again in about two or three hours time, becoming tense.

The nipple should be prominent and erectile. Sometimes it is too large, and a feeble child cannot draw it. More commonly it is small or flat, retracted, drawn in below the level of the surrounding tissues; in such cases suckling may be a mechanical impossibility.

Mental and Moral Attributes.—The perfect mother is placid and equable in temper, cheerful, good natured and active. She should be unemotional, or at any rate have her emotions well under control, and should possess a moderate amount of intelligence. She should be temperate in food and drink, though not necessarily a total abstainer. Above all she must have plenty of patience and a due sense that for the time being nursing must be her paramount duty, and that all other duties and amusements must be put on one side if they interfere with the proper performance of her functions as

a nurse. It is rare to find all the physical, mental, and moral characteristics of a good mother, except among the quiet unostentatious religious women of the middle classes. Such women, with their noble sense of duty to their helpless offspring, calm self-control and quiet faith, together with a sufficiency of the necessities of life, rarely fail to bring up their children satisfactorily.

Mode of Life.—This should be regular and placid. In the lower classes hard physical labour should, if possible, be avoided, but most of the ordinary housework can be done without ill effect, and even with distinct advantage. In the higher classes late hours, dinners, dances and other such entertainments must be avoided. It is impossible for a mother indulging in such amusements to nurse her child satisfactorily. Such a mode of life is quite incompatible with the regularity of nursing, so essential to success, and the irregularity in nursing and in diet, together with the excitement, leads to alterations in the quantity and quality of the milk secreted. Moderate exercise and driving in an open carriage should be taken, if the weather is warm enough, and are distinctly advantageous. The diet should be generous and easily assimilable, and excess of food should be carefully guarded against, if exercise is not taken. Indigestible food, such as new bread, pickles, pastry, pork, cheese, and such like, must be avoided, and tea only taken in moderation. Tea, if strong or in large quantities, is bad for nursing women. It may give rise to dyspepsia and mal-assimilation of food. Strongly aromatic foods, such as game, onions, and asparagus, and highly seasoned dishes must not be taken. An extra pint

of milk a day is generally necessary, and gruel, cocoa, or bread and milk at bed-time.

Sometimes stimulants are requisite or advisable. Of these porter or stout is the one generally recommended, while ale is said by some authorities to disagree. Frequently nursing-mothers, accustomed to taking ale with their lunch or dinner, find it a more satisfactory stimulant than the heavier liquor. Light bottled ale is the best kind to recommend. As a matter of fact almost any kind of stimulant can be taken in moderation and the only care necessary is to guard against excess. The effect of alcohol on the secretion of milk is referred to subsequently.

During the early days of lactation, while confined to bed, the diet should be one easy of digestion and not too solid. Not only is the mother at rest and requires less food, but also the infant wants a milk which is not too rich in solids.

CHAPTER III.

THE PHYSIOLOGICAL PROCESSES INVOLVED IN LACTATION.

The knowledge and clear understanding of the physiological processes of normal lactation are of essential importance; otherwise it is impossible, except purely empirically, to modify the percentage composition of the milk by alterations in the diet, or to regulate the frequency with which the child should be put to the breast.

Enlargement of the Mammæ during Pregnancy.—The normal mammary glands of a virgin, when fully developed, form two conical rounded eminences, placed one on each side of the anterior surface of the thorax. Each breast extends from the third rib above to the sixth or seventh below, and from the edge of the sternum to the axilla. As a rule the left breast is a little larger than the right. The size varies considerably, chiefly according to the amount of fat. The nipple is a prominent erectile structure, situated about the level of the fourth rib. It is rose pink in colour and surrounded by an areola of similar or darker tint, according to the complexion of the woman. This areola is studded with scattered rounded elevations or follicles formed by small glands. The earliest indications of any

change in the breast are vague sensations of fulness and weight. These may be experienced as early as the end of the first month. Sometimes there is considerable pain and tenderness. By the eighth or ninth week the nipples become enlarged and turgid, the surrounding areolæ are deeper in colour and larger, and their follicles are more prominent. The glands continue to gradually increase in size and the surface is marked by large blue veins, especially conspicuous in fair-complexioned women. All these changes are brought about by the greater flow of blood to the breasts and their greater functional activity.

The Secretion of Milk.—Sometimes a few drops of milk can be squeezed out of the glands during the early months of pregnancy. Usually secretion takes place in the last few months and occasionally so freely that it may be pressed out in jets from the nipple. The secretion during the first three days after delivery is called *colostrum;* it is scanty in amount and is of value to the newly born infant by virtue of its laxative and nutritive properties. Active secretion generally begins on the third or fourth day after delivery, and the amount of milk secreted increases to a certain extent with the age of the child. It is most active while the child is suckling.

The Abnormal Secretion of Milk.—Milk secretion is not an infallible sign of pregnancy. Nor is the presence of large mammary glands an infallible sign of the female sex. Hutchinson, in his *Archives of Surgery* for 1895, gives portraits of a man and a boy in whom the mammary glands were remarkably developed. Cases too are recorded of males whose

mammary glands have secreted considerable quantities of milk. Humboldt investigated and recorded the case of Francisco Lozano, who nourished his infant son at the breast for several months. Similar instances have been referred to in medical literature but are not as well authenticated.

Females, human and animal, occasionally secrete milk without having been previously pregnant. Joly and Filhol recorded the case of an old woman, aged seventy-five, who successfully reared her grand-child at the breast.

Sometimes the breasts of the new-born, and of boys and girls at puberty, are enlarged and hardened, and a few drops of a colostrum-like fluid can be squeezed out of them. Von Gesner gives the following analysis of the milk secretion of the new-born. All the usual constituents of milk are present in it, but in different proportions. It is sometimes called "witches' milk."

TABLE III.

The Milk of the New-born (VON GESNER).

Water	95·705
Total solids	4·295
Casein	0·557
Albumin	0·490
Fat	1·456
Sugar	0·956
Ash	0·836

Gubler and Quévenne give the total solids as 10·60; Schlossberger and Hauff found only 3·70 per cent.

Such milk can only be obtained in small quantities, hardly sufficient for reliable analysis, and no

doubt varies in composition in different infants according to the amount of water present in it.

The breasts of women with mammary tumours, simple or malignant, may yield a few drops of turbid or hæmorrhagic fluid, in which can be found round and epithelial cells, cholesterin and bacteria, but no fat. A continuous watery discharge, due to eczema of an atrophied or retracted nipple, may be mistaken for a secretion of milk. In breasts affected with chronic fibroid disease the formation of milk may not take place at all. Complete agalactia is sometimes seen in apparently normal healthy women.

The Physiological Processes taking place in the Gland.—These are very clearly described by Michael Foster in his "Text Book of Physiology," from which a considerable portion of this section is taken. In the gland of an animal that has never been pregnant the alveoli are smaller and less numerous than in the gland of a suckling animal. Each alveolus is composed of a solid mass of small polygonal cells. The growth of these cells is exceedingly slow and, the products of their metabolism passing into the blood stream, no secretion takes place. When the animal becomes pregnant numerous new alveoli are formed by a process of budding, solid masses of cells growing out from the original alveoli. Towards the end of pregnancy the central cells of the alveoli undergo a fatty metamorphosis, and either before or after birth, are cast off and leave a single layer of cells lining the alveolus. These cast-off cells form the so-called colostrum corpuscles. On microscopical examination of a section of an actively secreting gland the cells lining the alveoli are seen to vary much in size. An alveolus, emptied

of its contents, is lined by small cubical cells, and has a large lumen. As the formation of milk takes place the cells enlarge, become columnar and project more or less unevenly into the lumen, which is consequently irregular and small. Two or more nuclei may be present in these large cells and numerous oil globules in the cell protoplasm. These oil globules are extruded, and the cell itself undergoes imperfect division, part being cast off and entering the secretion.

The Physiological Processes affecting Lactation.—The secretion of milk is not a process of filtration, nor must it be supposed that the cells take the component parts of the milk from the blood and merely hand them on. It is a true metabolic process, the result of the metabolic activity of the secreting cells lining the alveoli of the mammary gland. These cells actually manufacture the milk from the nutrient materials brought to them by the blood. This assertion is supported, or even proved, by the following arguments and facts.

That the fat of milk is not necessarily derived from the fat taken in as food is very evident. Cows at grass yield a great deal more fat in their milk than can be accounted for by the fat in their food. Carnivorous animals secrete a milk rich in fat. A bitch fed on meat secreted more fat in her milk than she took as food, and at the same time gained weight, so the extra amount could not have come from her superfluous fat. Besides this it has been proved that the quantity of fat in milk is increased by proteid food and diminished by fatty food. Proteid food increases metabolic activity, whereas fatty food diminishes it. Fat can also be formed from carbohydrates. Histologically, the presence of fat globules

in the cells of the alveoli can be readily demonstrated. We have still further evidence of the formation of fat from protoplasm in the fatty degeneration occurring pathologically in various organs, such as the liver and heart. Possibly some of the fat may be taken up by the gland from the blood directly.

Caseinogen, another constituent of milk, is not found in the blood. It must therefore be formed by the metabolism of the cells. The other proteid constituent, lact-albumin, is in all probability formed or modified by the metabolism of the cells for, though closely allied to the serum-albumin of blood, it differs in several respects. When the normal activity of the gland is disturbed the percentage of albumin is increased at the expense of the caseinogen; so too at the beginning and end of lactation. In milk kept at 35° C. outside the body the caseinogen is said to be increased at the expense of the albumin. This statement requires confirmation. Similarly the carbohydrate of milk, lactose or milk-sugar, is not found in any other part of the body, except in the alimentary canal when it has been taken as food; nor has it been found in the blood. In carnivora it is present in abundance in the milk, although a very small quantity of carbohydrate food is consumed. It follows, therefore, that the lactose is only to a small extent, if at all, dependent upon carbohydrate food. All these considerations prove that the secretion of milk is a true secretion, dependent upon cell activity; that the metabolic processes in the cells are largely influenced by the nature of the food; and that an increase of one particular proximate principle of the food-stuffs does not necessarily produce an increase of the same proximate principle in the milk. It

must also be borne in mind that, like other secretions, the secretion of milk is controlled and modified by the nervous system.

Diet during Lactation.—It has already been stated that the mother requires a generous diet. For this purpose it is sufficient to encourage her to eat more fully of plain mixed food at the ordinary meal times, and to take a little lunch in the middle of the morning, and some cocoa, bread and milk, or milk gruel at bed-time. She has to maintain her own nutrition and to provide food for the child. Estimating that she may have to supply a litre of milk, containing about 2 per cent. of proteid, she will have to take about 60 grammes more proteid than she otherwise would need. Physiological chemistry teaches us that:—

	Nitrogen.		Carbon.
100 grammes of proteid yield .	15·5 gms.	...	53·0 gms.
100 grammes of urea . .	46·6 gms.	...	20·0 gms.

Therefore it requires three times the amount of proteid to provide the nitrogen for the urea excreted. This yields a large excess of carbon, namely 159 minus 20, equal to 139 grammes in 300 grammes of proteid, or 28 grammes in 60 of proteid. This excess carbon is available for fat formation. We may estimate that 60 grammes extra of proteid will provide the nitrogen to form 20 grammes of proteid for the milk-supply, and the remainder will be excreted as urea, the surplus carbon being used up for the formation of fat in the milk.

From this it is evident that a nursing-mother requires a greater supply of proteid than at other times, more especially for the due formation of the fat needful for the child.

An extra amount of carbohydrate food is also required. Although it has been shown that in the case of carnivorous animals the lactose in the milk cannot be accounted for by the amount of carbohydrate present in the diet, it is probable that in the human subject the presence of an extra amount of carbohydrate in the diet is advantageous to the formation of milk-sugar and fat. Carbohydrate is undoubtedly a fattening food, as has been proved by direct experiments on animals. The process by which fat is formed from carbohydrate is not, however, clearly understood.

An extra amount of fat in the diet appears to be rather a disadvantage than an advantage. Fat in the food diminishes the activity of proteid metabolism, and is mainly of use in the maintenance of the body temperature.

CHAPTER IV.

THE PHYSIOLOGICAL CHEMISTRY OF INFANTILE DIETETICS.

Food is required by adults for the production of energy in the form of work and heat, for the supply of secretions, for the repair of waste, and for the general maintenance of nutrition. The child requires food for all these purposes and, in addition, a supply to provide for its growth and development. It is not sufficient to give only enough to keep the body in a state of equilibrium. During the first year growth is very rapid, and in the growing child metabolism is two or three times more active than in the adult.

The child, therefore, requires more food in proportion to its body weight than the adult. The relationship of the different constituents of its diet to one another also varies, because of the extra need of heat-producing food during the early months of life, to counterbalance the deficient heat production from lack of muscular energy and the greater loss of heat by the skin, proportionately to the bulk of the body. The loss of heat by the skin varies directly as the superficial area and inversely as the body weight; the percentage loss is consequently greater in small animals than in larger ones. More than two-thirds of the loss of heat is due to conduction, radiation,

and evaporation from the surface. In proportion to weight the surface is quite three times greater than in the adult.

The physiological value of a food is equal to the sum of the physiological values of its component parts. Practically we may regard all foods as consisting of five component parts, which are generally known as the *proximate principles* of food; these are Water, Proteids, Carbohydrates, Fats, and Salts.

The value of a food also depends largely on the assimilability and this, again, upon the nature of the food, the mode of preparation, the mode of administration, the composition of the digestive juices, the condition of the absorbing surfaces, and the idiosyncrasy of the individual.

Thus, a food may have a high nutrient value at one period of life and at another be useless, or even injurious, from inability of the consumer to digest it.

Water.—For our present purpose we may regard water as a pure compound of hydrogen and oxygen. As a matter of fact ordinary water is crowded with micro-organisms and contains various salts. The proportion of salts varies in different districts.

Water is not primarily a source of energy, nor is it nutritious in the ordinary sense of the term.

It is essential to life and constitutes more than half the entire body weight. The physiological activity of a cell depends upon a due supply of water. Abstract water from an amœba and it enters into a condition of "dry rigor," it becomes physiologically inactive.

Water is lost to the economy in sweat, in the expired air and in the excreta. Proportionately to its weight the infant requires much more than the

adult, about six times as much; the relationship of the body surface to the body weight being considerably greater, and therefore the loss of moisture by the skin more in proportion.

Common sense teaches us that when the ordinary processes by which water is eliminated are increased there is need for an increased supply of this fluid. Thus, in the sweating of rickets and febrile conditions, in respiratory affections and in infantile diarrhœa, the amount of fluid ingested should be increased. The rapid wasting in infantile diarrhœa is largely due to the elimination of water. The equally rapid recovery, when the diarrhœa stops, is similarly due to the absorption of fluid from the alimentary canal.

Both in winter and summer nursing infants are liable to suffer from thirst. It is not necessary, sometimes it is even injurious, to give the crying babe food in the shape of milk when all that it requires is a drink of water. If it is fed when it is merely thirsty its stomach is liable to be overstimulated and indigestion results. Sometimes the thirst is due to indigestion, and more food will make it worse. It is a good rule whenever an infant, at the breast or hand-fed, cries between its meals, to offer it a drink of plain boiled water, which may be given hot or cold—but not too cold, not iced.

To a large extent water assists in digestion. From 80–90 per cent. of the food of the young is water. Consequently the food is very dilute and easy to digest. Water increases the secretion of pepsin and hydrochloric acid (Jacobi) and assists in the pepsin digestion of proteid. It is of great value as a solvent and diluent of food substances, and thus assists in

absorption from the alimentary canal. It is an incentive to elimination, and is especially indicated in the new-born on account of the liability to uric acid infarction in the kidneys, or to gravel and attacks of renal colic. It acts as a solvent of salts for elimination by the kidneys and skin, and should be given freely when the secretion of urine is scanty.

It is useful in cases of marasmus in order to keep the blood in a fluid condition and lessen the liability to thrombosis.

It promotes activity of the circulation of fluids and increases cell metabolism. It acts as a diluent of the intestinal contents and helps to prevent constipation. Many cases of constipation in infants can be cured by simply increasing the amount of fluid ingested, by the administration of water. In this connection it acts by keeping the intestinal contents liquid or by diluting the food and rendering it more digestible.

Infants rarely suffer from excess of water. In some acute cases of gastro-enteritis it may be necessary to enforce total abstinence for six to twelve hours.

If it cannot be given by the mouth it may be injected into the rectum in doses of one to two ounces, every one or more hours.

Proteid is the form of food in which nitrogen is supplied to the body. It contains nitrogen, carbon, hydrogen, oxygen, and sulphur. Proteid food is especially needed, for nitrogenous matter is essential to the structure of protoplasm and enters into the structure of every cell. All the tissues of the body are formed by cells or modifications of cells. Consequently the child requires even more proteid, in

proportion to its weight, than the adult, who has only to maintain equilibrium of tissue, whereas the infant has to provide for the building up of new tissue. An adult man, of 67 kilogrammes weight, requires about a hundred grammes of proteid daily. An infant of 6·7 kilogrammes, the weight of a child about six months old, takes 1000 grammes of milk daily, containing 20 grammes of proteid; much more proportionately than the adult. So too the growing child requires a free supply of proteid food, more proportionately than the adult, and yet very commonly it gets less. Development depends very largely on the percentage of proteid in the milk. An infant doubles its weight in five months on 1–2 per cent. of proteid; a calf doubles its weight in one to two months on 4 per cent.

The chief proteids are the myosin of meat, casein and lact-albumin of milk, egg albumin, and the various proteids of blood. In addition to these animal proteids there are certain vegetable forms, such as gluten, vegetable myosin and others. Vegetable proteids are free from crystalline extractives, but they are not as valuable as animal proteids. The latter are the more digestible. As a rule, the more they are altered by cooking, the more difficult of digestion they become. Raw eggs, for instance, are more digestible than when boiled. The most digestible proteids are those of human milk.

All the proteids taken into the stomach are not necessarily digested and assimilated. Even in an infant at the breast a considerable proportion of the proteids of the milk may be found in the fæces.

At present the data for estimating the amount of proteid absorbed by the infant are insufficient. The

difficulties in obtaining the urine of an infant for a period of twenty-four hours are so great that the percentage of urea and the amount passed in the day have not been accurately ascertained. It is, however, proved that the infant excretes a much smaller percentage of urea than the adult, although taking a greater percentage of proteid food. The urine may be collected by mechanical pressure with the hand over the bladder from above downwards when the infant wakes up from sleep, or by means of a No. 2 English catheter.

The total daily excretion of urea would neither indicate the total amount of proteid digested, nor be a measure of the amount utilised in the maintenance of equilibrium of tissue and the amount devoted to the purposes of growth. In order to carry out the investigation in a satisfactory manner, it would be first of all necessary to find out by exact experiment the minimum amount of proteid needed by the child to maintain its nitrogenous equilibrium. The next step would be to increase the amount of proteid and estimate the effect on the growth. It is evident that such an investigation is beset with difficulties, and the sources of error in carrying it out are very numerous.

Effects of Deficiency of Proteid Food.—The child becomes anæmic, languid, debilitated and short of breath on exertion. The muscles are soft and flabby and the child ceases to grow. Dentition is delayed and rickets may develop, for the salts are diminished if the proteids are deficient. In the case of boys at school the absence of the ordinary gain in weight and height is a very fair indication that the school diet is deficient in proteid.

Effects of Excess of Proteid Food.—In infants too great a proportion of proteid in the milk leads to indigestion, colic, and constipation. The stools are green or yellow, and contain curds. This is more especially the case when the caseinogen is in excess. Excess of uric acid in the urine, gravel and renal colic may also occur.

In older children evil results are uncommon. The active metabolism of the growing child enables it to dispose of an excess of proteid with comparative ease. Some cases of headache and migraine in children are connected with too liberal a proteid diet. Renal colic is of occasional occurrence.

Bodies Allied to Proteids.—Of these gelatin is the most important. It enters into the composition of many articles of diet, such as beef-tea, soups and broths, jellies and many blanc-manges. It possesses a certain nutritive value and can replace proteid to a considerable extent, but not entirely. If the proteid in the diet be entirely replaced by gelatin the animal dies.

Fats.—One of the chief requirements of the infant is the maintenance of the bodily heat; should this fail the child rapidly succumbs. The two great food-stuffs for the production of heat are the fats and carbohydrates, and of these fat is the more valuable, by virtue of the large amount of carbon which it contains. Sugar is the more digestible but fat has the greatest potential energy. Fats are much poorer in oxygen and richer in carbon and hydrogen than the carbohydrates, and therefore their heat value is proportionately greater. Heat is essential to life, and all the vital processes are more active at the temperature of the body than at a lower tem-

perature. This is more especially the case with the muscular and nervous systems. Fat enters largely into the structure of nervous tissues and bone marrow. Red corpuscles are formed in the red marrow of bones. Though we have no proof that the fat in the tissues and stored up in the body is formed from the fat taken in as food, it is well known that the fat stored up is soon drawn upon if the food is deficient, and hence the tissues may suffer indirectly. Fats also aid in the absorption of inorganic salts, especially earthy phosphates, from the alimentary canal. If the fats are deficient more of these salts are found in the fæces. Fat is of further value in diminishing nitrogenous waste. If given in proper amount a greater percentage of proteid is utilised for nutrition and growth. If the fat is deficient the proteid is drawn upon for the maintenance of animal heat.

As a rule fat is very completely absorbed; not invariably so, for it is frequently found in the fæces of infants at the breast or artificially reared, in considerable quantity, about 10 per cent. of the total fæces. There is often more fat in human milk than is necessary. A certain amount is essential to secure regular soft fæcal evacuations. Sometimes the administration of an extra amount of fat in the food, in the form of cream, will remedy constipation. An infant weighing 6·7 kilogrammes takes in its milk 40 grammes of fat, whereas an adult weighing ten times as much does not require more than 100 grammes, that is, twice to three times as much as the infant. The reason is that the infant cannot maintain its bodily temperature by exercise in the same way as the adult can.

Effects of Deficiency of Fat.—In artificial feeding, as usually employed, the fat is very deficient in amount. The result is that the digestion is not so good, constipation may be present, earthy phosphates appear in the stools, and nutrition suffers. Deficiency in fat is often regarded as the cause of rickets. It may be so in most cases, but is certainly not the sole and invariable cause. Cases have come under my notice in which rickets has been well marked, and yet the infant has taken even an excessive amount of fat in its food. On the other hand, rachitic infants are remarkably benefited by the addition of fat, especially cod-liver oil, to their food without any other change being made in their diet or surroundings. That it is essential to the perfect development of the young animal is evident from its presence in the milk of the suckling mother.

Attempts have been made to remedy the deficiency of fat in the mother's milk, or in the artificial mixture given to replace it, by the addition of carbohydrate food. Such a substitution is theoretically sound, if fat is regarded as a source of heat only. The proportion of additional carbohydrate required for this purpose can be readily calculated. Clinical results prove, however, that such a substitution is unsatisfactory, and that carbohydrate cannot replace fat to the advantage of the child. The best instance of this is the prevalence of rickets among infants brought up on sweetened condensed skim milk. Many cases of rickets are met with in children who have been brought up on a diet containing a due supply of proteid, a deficiency of fat, and an excessive amount of cane sugar.

Excess of Fat.—Artificial mixtures, as usually ordered, so rarely contain an excess that it is quite exceptional to come across cases of vomiting and diarrhœa, due to this cause, in infants brought up by hand. Results such as these do occasionally occur in infants brought up at the breast. The mother's milk may contain too high a percentage of fat, even 6 to 7 per cent. Generally at the same time there is an excessive proportion of proteid, and it is difficult to ascertain whether the digestive disturbance is due to the excess of fat, the excess of proteid, or to the two causes combined. Too free administration of fat in the food may give rise to a variety of diarrhœa, described by the Germans as "fat diarrhœa," and characterised by the presence of a large quantity of fat in the stools. It is usually associated with simple intestinal catarrh. Impairment of digestion, vomiting, diarrhœa and wasting, may be due to excess of fat in the food.

Carbohydrates.—This group of food-stuffs is of value for the production of heat, and as a source of muscular energy. In a child at the breast its chief value is for the production of heat; in an older child it is required for the two purposes. Physiological experiments have shown that in the production of muscular energy the grape sugar in the blood is carried to the muscles and then burnt up or oxidised. The infant weighing 6·7 kilogrammes takes about 70 grammes of carbohydrate in its milk; the adult of ten times the weight requires about 240 grammes, and more in proportion to the amount of muscular work he performs.

Infants practically never suffer from deficiency of carbohydrate food, the percentage in human milk

varying within comparatively small limits; in artificial feeding there is more commonly an excess.

Leeds, from the analysis of the milk of a large number of women of different ages and nationalities, and at different periods of lactation, found the following variations in the chief constituents :—

TABLE IV.

The Variation in the Chief Constituents of Human Milk (LEEDS).

	Proteid.	Sugar.	Fat.
Maximum . .	4·86	7·92	6·89
Minimum . .	0·25	5·40	2·11
Average . . .	1·995	6·936	4·131

It is very striking how small is the variation in the percentage of sugar, compared with the variations in the percentages of fat and proteid.

Effects of Excess of Carbohydrate Food.—Excess of sugar in human milk rarely produces any ill effect. Some of it may be eliminated unchanged. Infants during the first year of life suffer largely from the evil results of excessive carbohydrate food, when brought up partially or entirely by hand. Almost all the condensed milks and patent foods in the market, each widely advertised as the best, contain an excess of carbohydrate, generally in the form of starch or cane sugar. Almost all the infants fed upon these foods become fat, flabby, unwieldy and rachitic. This excess of carbohydrates frequently induces intestinal disturbance and fermentative changes in the food while in the alimentary canal, with the production of flatulence and offensive diarrhœa.

Milk Sugar *versus* **Cane Sugar.**—In artificial feeding lactose or milk sugar is sometimes added to the diluted food in order to raise the percentage of carbohydrate to that in human milk; more commonly cane sugar is employed. Commercial milk sugar is often impure, and its mode of preparation leads to considerable contamination. It contains many crystallisable salts, and it may not be absolutely identical with that of human milk. There is evidence in favour of the view that the sugar in human milk is not lactose. Cane sugar is cheaper, more handy and sweeter. On account of its sweetness it cannot be given in such large quantities as lactose. It is impossible to speak with certainty as to whether any injurious effects result from this substitution of cane sugar for milk sugar, as long as the proper percentage of the one or the other is given. Although lactose and cane sugar belong to the same group of carbohydrates, namely, the saccharoses, with the formula, $_n(C_{12}H_{22}O_{11})$, yet physically and chemically they are very markedly different from each other.

In addition to this they undergo different kinds of fermentation. Cane sugar readily undergoes alcoholic fermentation; and butyric fermentation more easily than lactose. Solutions of the same strength as those usually given to infants readily ferment *in vitro*. Milk sugar is rapidly converted into lactic acid, and causes the souring of milk. Possibly there are several kinds of lactic acid just as there are many varieties of bacilli causing this kind of fermentation. Milk sugar ferments very much more readily than cane sugar, which indeed is used by the manufacturers of patent foods as a

preservative. Lactic acid fermentation is easily stopped by heat. According to Brush lactose ferments less readily than cane sugar.

Cane sugar cannot be utilised as such in the body, it requires conversion in the alimentary canal. The change takes place chiefly in the small intestine, saccharose being converted into dextrose, in which form it is absorbed. Possibly lactose can be used directly for nutrition without such conversion. Experiments by Claude Bernard are in favour of this view. He injected seven grains, dissolved in an ounce of water, under the skin of a rabbit and found that no sugar appeared in the urine. Using cane sugar in a similar experiment, he found that it was eliminated in the urine. More recently F. Voit has shown that both lactose and cane sugar appear in the urine after subcutaneous injection of a 10 per cent. solution. The question remains undecided. It may be argued that cane sugar is injurious on account of its rapid fermentative changes; or that it is a valuable method of giving carbohydrate, because it so rapidly undergoes conversion, and is consequently easily digested and assimilated. Clinical observation shows that it is of very great value as a food for both infants and adults.

My own experience is that cane sugar can replace lactose without any ill effect, provided that it is given in proper proportion, and that the digestive disturbances, which arise in infants taking cane sugar, are due to an excessive amount rather than to its chemical composition. Being cheap and handy and pleasant to the taste, there is every temptation to give the child more than is good for it. Starchy foods are referred to subsequently.

Salts.—Various observers have analysed the salts present in milk. Chief among these ranks Bunge, who established the remarkable fact that the percentages of the salts in the ash of the newly born animal are practically the same as the percentages in the ash of the mother's milk. Certain exceptions are noticeable and important. The ash of the milk contains more potassium and less sodium salts. The explanation of this difference lies in the fact that, as the animal grows, there is a relative increase in the muscles which are rich in potassium, and a diminution in the cartilages which are rich in sodium.

Another very important difference is the percentage of iron. The proportion of iron in the ash of the newly born animal is very much greater than in the ash of the mother's milk. This deficiency of iron in the milk is counteracted by the young animal storing up iron in its liver previous to its birth. Bunge has found that the percentage of iron in the ash of animals of the same litter diminishes with the increase in the growth of the animal; showing that this previously stored-up iron is required to make up for the deficiency in the iron in the mother's milk.

Animals can live on milk but die if the salts are extracted. Even if the salts, after extraction, be added, the animal cannot live on the mixture, for the organic combination of proteids and salts is destroyed. In order to be utilised it is almost certain that the salts must be combined organically with some form of proteid. Hence, deficiency of proteid in milk may be associated with deficiency in assimilable salts.

Sodium Chloride.—There is a much larger proportion of this salt in cow's milk than in human milk, so much so that it is not necessary to add common salt to cow's milk in artificial feeding. According to Bunge the proportion is as six to one. The addition of salt has, however, some advantages. It acts as a stimulant to the appetite and increases the secretion of hydrochloric acid, thus assisting in digestion. It aids in the solution of globulins in the blood; this group of proteids being insoluble in distilled water, but soluble in dilute saline solutions. When added to milk it diminishes its coagulability with rennet ferment and gastric juice, and may therefore be of advantage in the artificial feeding of infants with weak digestion.

It is a curious fact that all carnivorous animals, and people who live a nomad life on a diet consisting mainly of flesh, require no additional salt with their food. Herbivorous animals, and people who live on a vegetable or mixed diet, take a considerable quantity of salt in proportion to the amount of vegetable food. Vegetable food contains much potassium salt, and the sodium salt is required to neutralise its effects. It is important, therefore, to add salt to the diet of an infant who is given vegetable food with its diet, such as barley water, &c. There is one cereal which contains remarkably little potassium, namely, rice. It contains six times less than the common cereals, wheat, oats, and barley, and ten to thirty times less than the leguminosæ and potato. The latter vegetable contains a very large amount of potassium salts.

Iron.—Both human and cow's milk contain a very small proportion, 0·003 per cent., of the dry

solids. Hence, when cow's milk is diluted, the percentage of iron is reduced below that present in human milk. The iron exists in the milk in the form of organic compounds.

Deficiency of iron in the food of hand-fed babies may produce anæmia and debility. To guard against this iron must be given by the mouth and, seeing that normally it is taken in the form of organic compounds, it is better to administer it in this form rather than to give inorganic preparations. It is doubtful whether iron introduced in the form of inorganic salts can be converted into hæmoglobin by synthesis. Organic ferruginous combinations exist in yolk of egg in the form of nucleo-albumins. In yolk of egg are food materials containing all the ingredients necessary for the development of the fœtal chick. It is rich in fat and contains lime salts, phosphates and iron. Analysis shows that there is a considerable quantity of iron, 0·04 per cent. of the dried solids. The addition of this, boiled or unboiled, will probably be quite sufficient to remedy the deficiency of iron in the food, and will also provide other easy digestible nutrient principles.

In blood and raw meat juice iron is contained in considerable quantity in the form of hæmoglobin. In this combination the iron is more firmly held than in the nucleo-albuminous compound present in the yolk of egg. Nevertheless, raw meat juice or the red gravy of undercooked meat is a valuable addition to the diet for the prevention or cure of anæmia. After the age of one year potatoes, containing 0·042 per cent. of iron in the dry solids, can be added to the

diet. About 0·02 per cent. of iron is present in lean meat, cereals, and leguminosæ, such as wheat and peas.

Lime.—In human milk 0·0243 per cent. is present, in cow's milk 1·51 per cent., and in yolk of egg 0·38 per cent. Meat, cereals, and leguminosæ contain a much smaller proportion. It is doubtful whether a child brought up on a diet devoid of milk, would obtain the amount of lime requisite for the proper development of its bones. The phosphates of lime and magnesium are most important for cell growth and bone formation.

It is uncertain if this salt can be absorbed except in the form of organic compounds, and it is exceedingly improbable that it is absorbed, dissolved in water. There is no evidence that water, rich in lime salts, has any value whatever in the prevention of rickets. Lime water, in saturated solution, does not contain as much lime as cow's milk. Consequently the addition of this fluid to milk can exert no influence, except by virtue of its alkalinity. Lime is more soluble in cold than in hot water. When the lime water is warmed, by adding it to hot milk, some of the salt is precipitated. The lime salts in milk are rendered more insoluble by prolonged heat, as in sterilisation.

Phosphorus.—This salt is of the utmost importance in the formation of the bones, and probably in the prevention of rickets; so much so that it has been prescribed for rickets and, according to some observers, with considerable success. As a rule it is given with cod-liver oil, and at the same time careful attention is paid to diet and hygiene, so it is extremely doubtful that the good effects noticed

have been due to the phosphorus. Six times as much is present in lean beef, yolk of egg, and cow's milk, as is found in human milk. Cereals, leguminosæ, and potatoes contain considerably more phosphorus than human milk. Lecithin and nuclein are bodies containing phosphorus, and are found in considerable quantities in nervous tissues and ova. It is not known whether they are digested and absorbed, but it is certainly harmless to give calves' brains and hard roes of fish to children. Nuclein is present in milk but, according to Koplik, the nuclein of cow's milk is not assimilated by the infant. Hence rickets may arise in the bottle-fed from non-assimilation of the phosphorus. The large amount of phosphorus present in cow's milk indicates that dilution to the extent usually practised will not render the supply of this salt deficient. If it is thought that more is required, it is much simpler to administer the salt in the form of yolk of egg than in the form of inorganic compounds, and in all probability this is better digested and assimilated.

The Composition of an Infant's Diet.—In several respects this differs from the diet of an adult. The proportion of the different constituents to each other and to the body weight is different.

The requirements of an adult diet are variously estimated by physiologists. For the purposes of reference and comparison the best known estimations are given in the following table.

TABLE V.

Constituents of an Average Adult Diet.

	Van Ranke.	Moleschott.	Pettenkofer and Voit.	Waller (for a man of 70 kilos. weight).
	Grammes.	Grammes.	Grammes.	Gms. Per ct.
Proteid .	100	120	118–137	140 or 0·2
Fat . .	100	90	50–117	105 ,, 0·15
Carbohydrate .	250	330	352–500	420 ,, 0·6
Salts .	25	20	—	35 ,, 0·05
Water .	2600	2800	2016	2100 —— 1·0 solid food.

Moleschott's diet yields 18·88 grms. of nitrogen and 281·20 grms. of carbon. Von Ranke's diet yields 15·5 grms. of nitrogen and 225 grms. of carbon. Waller's diet is more liberal with each element of food. He calculates roughly that a man in full work requires an amount of food equal to about 5 per cent. of his body weight.

An infant's diet may be estimated as follows. Allowing that a healthy infant, aged six months, takes a litre of milk daily and calculating from Leeds' average analysis of human milk, the composition of an infant's diet at this age will be :

TABLE VI.

Diet of an Infant aged Six Months, Weight 6·7 kilogrammes.

	Grammes.
Proteid	20
Fat	40
Carbohydrate	70
Salts	2
Water	868

On comparing this with the adult diet it is seen that the infant requires a much more liberal supply of each of the constituents of the ordinary diet in proportion to its weight, and a much more liberal supply of fat and water, compared with its need for proteids.

Halliburton estimates the needs of an infant under a year and a half old as 20–36 grms. of proteid, 30–45 grms. of fat, and 60–90 grms. of carbohydrate. At present it is impossible to give more definite figures, and it must be remembered that the requirements of the individual child may vary to some extent from the average. In regard to proteid Waller has pointed out that in proportion to body weight the amount required by the infant is greater than that required by the adult, but that in proportion to body surface the amount is approximately the same. Body surface is therefore a better proportional indicator than body weight.

CHAPTER V.

THE MANAGEMENT OF BREAST-FEEDING.

This part of the subject must be considered from two points of view, viz., benefit to the child and the prevention of any deleterious effect on the mother. In the present chapter the infant is chiefly considered, and the contra-indications to breast-feeding will be dealt with subsequently. On the due appreciation of the management of the natural method of feeding infants depends the health of many a child. With such knowledge it will be found practicable to bring up on the breast many children, who would otherwise be weaned unnecessarily to their great disadvantage.

The Early Application of the Child to the Breast.—Let the child be put to the breast as soon after birth as the mother has recovered somewhat from the fatigue of labour, probably in a few hours' time. Several advantages are gained by such a mode of procedure. In the first place the excitation of the nipple reflexly induces uterine contractions and so diminishes the liability to post-partum hæmorrhage. Secondly, the child has an opportunity of drawing out the nipples if they are at all small or retracted. In a few days the swelling of

the breasts caused by the rapid formation of milk, usually occurring on the third day, may make the nipples so depressed below the level of the surrounding tissues as to render it difficult or even impossible for the child to get hold of them. Thirdly, a small amount of thin watery *colostrum* is obtained by the infant. This fluid has a certain nutritive value, sometimes sufficient to enable the child to gain weight from its birth. It also has a valuable laxative action and assists in the expulsion of the meconium. It is absolutely unnecessary, and often decidedly injurious, to give the newly born infant castor oil or any other purgative drug, or that concoction of butter and brown sugar which is frequently the first food the child makes acquaintance with after its introduction into the world. Such treatment may form the starting-point of troublesome gastric and enteric disturbance, which may even end fatally. Fourthly, the withdrawal of a small amount of fluid may relieve the mother, should she suffer from painful distension of the breasts. Finally, the irritation of the nipple produced by sucking stimulates the secretion of milk.

No Artificial Food.—Nothing, not even milk and water, is to be given. Seeing that the secretion of milk is not established before the third day it is evident that no food, other than the colostrum obtained from the breasts, is required before that time. Food given diminishes the activity of suckling and the consequent stimulation of milk-production. Usually on the fourth day milk is secreted in abundance and regular lactation commences. Boiled cooled water may be given with advantage in the intervals between the nursings. If after the third

day the supply of milk is insufficient for the requirements of the child, it may be supplemented by giving a little cow's milk or cream, diluted with water and sweetened with milk sugar or cane sugar. The mode of preparation of this mixture will be referred to later. In such circumstances the child should be fed every two hours, being put to the breast and given a small quantity of the mixture alternately. In the case of very weakly infants a little food must be given even during the first three days of life. A teaspoonful or two of a five per cent. solution of milk sugar is the most suitable at this time. Such extra feeding is very rarely necessary and should only be given under medical advice and supervision.

Premature infants almost always require artificial food from birth, partly on account of extreme feebleness and inanition, partly because the child may not have sufficient strength to obtain its natural supply of food; and partly because the secretion of milk may not be quickly established.

The Method of Suckling.—In applying the child to the breast a definite method must be employed and certain precautions observed. The mother should sit down. The child should be held partially on its side, with its head and back supported, on the right or left arm of the mother, according as it is fed from the right or left breast, and the mother must bend her body somewhat forward so that the nipple may fall easily into the infant's mouth. The breast must be steadied by means of the index and middle fingers of the disengaged hand, placed above and below the nipple. Sometimes the milk flows too freely and the child, taking it down in big gulps

and too quickly, is liable to vomit it up again. This can be prevented by a little suitably applied pressure with the supporting fingers. If the milk flows with difficulty and the child cannot draw it, a little gentle pressure on the breast will assist the flow.

The Duration of each Nursing.—No hard-and-fast rule can be laid down as to how long the child should be kept at the breast for each meal. The time varies with the strength of the child, the rapidity of suckling, and the quantity and quality of the milk. A healthy child taking milk from a full breast may nurse until satisfied. It should be kept awake until it is satisfied and not allowed to go to sleep with the nipple in its mouth. The usual duration of each nursing is from ten to twenty minutes.

The Frequency of Nursing.—During the first few days after birth the infant may be put to the breast every two hours while the mother is awake or, if a very feeble babe, as often as every hour and a half. Some writers recommend that on the first day the breast should be given every six hours, on the second day every four hours, and after that every two hours. The more frequent nursing during the first two days is decidedly advantageous to the child and stimulates the secretion of milk. It is not necessary to wake the child and insist on it being nursed every two hours. When the secretion of milk is fully established the frequency of suckling may be lessened, as in the accompanying table. (Table VII.) Some infants will require feeding less frequently, but very great circumspection must be employed in lengthening the intervals, and even more

in shortening them. It is a very common custom to give the child the breast whenever it cries, on the assumption that the child's cry indicates hunger. Too much stress cannot be laid upon the importance of making the mother understand that much more often the cry is due to the pain of indigestion, caused by the indigestible character of the milk, and that this quality of the milk is induced by too frequent nursing. The pain of indigestion can be relieved by the administration of any warm fluid, such as breast-milk or hot water, but the warm milk only gives relief by virtue of its warmth and, by introducing more indigestible matter, induces fresh colic in a short time.

TABLE VII.

Time Table for Breast-Feeding.

Age 1–4 weeks.	Age 1–2 months.	Age 2–9 months.
5.0 A.M.	5.0 A.M.	5.0 A.M.
7.0 "	7.30 "	8.0 "
9.0 "	10.0 "	11.0 "
11.0 "	12.30 P.M.	2.0 P.M.
1.0 P.M.	3.0 "	5.0 "
3.0 "	5.30 "	8.0 "
5.0 "	8.0 "	11.0 "
7.0 "	10.30 "	
9 0 "		
11.0 "		

Occasionally with very feeble infants, and still more rarely in the case of very vigorous children with active digestive organs, it is necessary to allow the breast to be given once during the six hours' interval at night. During the later months of lactation the 5.0. A.M. nursing may be omitted if the child sleep soundly until later.

Some infants do not require feeding as often. I have met with a few who have progressed perfectly satisfactorily on five feeds a day, at intervals of four hours from five in the morning to nine at night, sleeping soundly for eight hours every night. Such cases are rather exceptional, but illustrate the necessity of not holding to a hard-and-fast rule, although it applies to the large majority of infants.

Regularity in Feeding.—This is found in practice to be a matter of the utmost importance to successful breast-feeding. If the duration of the intervals is irregular, both the quantity and the quality of the milk vary considerably. Too frequent suckling stimulates the cells of the mammary gland to excessive activity. The result of this is, as will be shown later, that the milk is altered in composition, the percentage of proteid being increased and the milk rendered indigestible. Besides this drawback, the child's stomach is not allowed sufficient time for the digestion of its contents if it is refilled too often.

With a little patience the child can be accustomed to being fed at fixed times and will wake up for its meals with the regularity of clock-work. It can also be accustomed to sleeping through the six hours' interval at night, and the mother is thus enabled to get a good night's rest. An interval of six hours is of advantage to the infant, by giving its digestive apparatus a period of quiet.

Sometimes the objection is raised that the child is asleep when its meal is due and that it cannot be awoke and kept awake sufficiently for it to take a proper meal. Consequently it awakes again hungry in about an hour. It is certainly advisable, if the child is asleep when the breast is due, to awake it

rather than allow the interval between the feeds to be prolonged. If the child cannot be kept awake, care must be taken not to allow it to suck for as long a time at subsequent nursings, and it will then wake up hungry at the time when its meal is due. Both the child and the mammary glands should be trained to exact regularity. When the interval is prolonged, whether on account of the child sleeping or for other reasons, the amount of milk secreted is increased and the child, when it does take the breast, is very hungry. Consequently it sucks greedily, rapidly fills or overfills its stomach, and then is either sick or gets an attack of indigestion. In some cases these very sleepy infants need not be fed more often than once in four hours.

At night time the child should sleep in its cot by the side of its nurse and not in the same room as the mother, if a nurse is available. The mother might be disturbed in the night by the child's cries, and the temptation to give the breast to stop the cries is almost irresistible and likely to be encouraged by the unfortunate tired husband.

The Duration of Breast-feeding.—Provided that the mother is perfectly healthy and strong, that the secretion of milk is sufficient for the wants of the child, and that the milk is of such a quality as can be readily digested and assimilated by the child and also sufficiently nutritious, suckling may be continued for nine months and partial suckling for twelve months. Except under special medical advice, breast-feeding should never be continued beyond twelve months, and usually it is advisable to discontinue it at the end of ten months.

Lactation is a normal physiological process and it

is comparatively uncommon for a mother to be unable to suckle her child during, at any rate, the first few months of its life. The younger the infant the greater is the importance of breast-feeding. Milk in some respects may be spoken of as a living fluid and differs from the artificial mixtures given to replace it, in that, as a result of the heat to which they are subjected, they are converted into dead fluid. Artificial mixtures will not therefore have the same nutrient value as freshly secreted human milk of the same chemical composition. If artificial feeding is required it should be postponed as long as possible. By the fourth or fifth month the child's stomach becomes more fully developed as a receptacle for food and its digestive powers are stronger.

Frequently from various causes the mother's milk becomes unsuitable. This can often be remedied by alteration in the diet, in the mode of life, or in the frequency of nursing.

Unduly prolonged suckling is injurious to both mother and child. The mother, on account of the prolonged drain on the system, may develop headache, anæmia, debility, muscular pains and increased susceptibility to disease. Amaurosis, epilepsy and insanity are occasional sequelae. The child may suffer on account of the deteriorated quality of the milk and the consequent insufficiency of its diet. Among the lower classes it is by no means uncommon for the child to be suckled for two years, sometimes even two and a half or three years. This is largely due to the prevalent idea that conception does not occur while the child is at the breast, whereas it often happens that the mother conceives again two

or three months after delivery, although she is suckling.

According to observations on this subject by Remfry, impregnation does not take place so readily during lactation as at other times, but this is not true to such an extent as has been imagined.

TABLE VIII.

The Occurrence of Impregnation while Suckling (REMFRY).

Amenorrhœa is present in . .	57 per cent.
Catamenia return in . . .	43 "
Regularity is present in . . .	20 "

Chances of Impregnation.

If amenorrhœa is present . . .	6 in 100
If the catamenia return . . .	60 in 100

The more regular the Woman the greater the chance of Impregnation.—These results show that suckling women can conceive although the catamenia have not returned; that to a certain extent suckling women are less liable to conceive, seeing that amenorrhœa is present in more than half; that the return of the menses is the best indication that the mother may again conceive, and that under such circumstances the continuation of suckling has probably no effect in preventing impregnation.

The Disadvantages of Breast-feeding.—These are mainly dependent on causes already referred to. Prominent among them are gastric disturbance and irritation in the infant, due to irregularity in feeding; colic, due to milk too rich in proteid matter; and other disturbances due to the various causes which induce altered conditions of the milk. It

must be remembered that easily digested breast-milk is not always sufficiently nutritious for the child, by reason of its too small percentage of solid constituents and, on the other hand, that milk too rich in solids may be very nutritious and yet not easily digestible. If the intervals between the nursings are too prolonged, the milk becomes poor in solids; if too much shortened, the percentage of solids is increased and the proportion of water diminished. What many mothers find the chief objection to bringing the child up on the breast is the necessary interference with their amusements and pleasures. Their whole life must be governed for the time being by the requirements of the infant. The excitement of a theatre or the digestive exertions of a dinner-party may be quite sufficient to render the breast-milk indigestible or insufficient in quantity. The temptation to advance the time for the nursing in order to get out and to postpone the time for the next meal in order to prolong the period of entertainment is readily, if not unavoidably, yielded to. It cannot too forcibly be insisted upon that one lapse from virtue in this direction may lay the foundation of troublesome digestive disturbance or diarrhœa. It is mainly due to this cause that the women of the upper classes so rarely bring their children up at the breast and give them the advantage of a thoroughly healthy start in life.

CHAPTER VI.

THE CHARACTERS AND COMPOSITION OF HUMAN MILK.

HUMAN milk is a thin, watery, bluish-white, faintly alkaline, sterile fluid, with a peculiar taste and odour.

The specific gravity ranges between 1030 and 1035, generally 1031, at 15° C. It varies a little with the temperature. With a very low percentage of fat and a high percentage of sugar it may reach 1042. If the percentage of fat is very high the specific gravity may fall as low as 1024. Monti took the specific gravity of the milk of a large number of women. He obtained 10 cc. to 20 cc. of milk immediately after suckling, put it in a glass tube warmed to 15° C., and floated in it Quévenne's Lactodensimeter. The specific gravity ranged between 1030 and 1034. Milk obtained at this period of nursing is of the nature of strippings and rich in fat. Monti's results may therefore be rather below the average. Ordinary variations in the specific gravity depend upon the proportions of the different constituents. An excess of proteids, sugar or salts, will raise it; an excess of fat will lower it. As a matter of fact, the amount of sugar and salts varies only within small limits, the difference in the

quality of the milk depending chiefly on the proportions of fat and proteid. Hence, by estimating the specific gravity and the percentage of fat, a very fair estimate of the quality of the milk can be arrived at. Monti considers that milk containing 3 to 5 per cent. of fat and having a specific gravity of 1030–1035 is good and useful for the child. Cases in which the milk is of high specific gravity and the percentage of fat low do not thrive. This, no doubt, is due to too high a percentage of proteid.

Morphological Characters.—Microscopical examination shows that milk consists of two parts, minute fat globules floating in a clear fluid or plasma. The fat globules vary in size from 0·00015 to 0·005 millimetres in diameter. They are usually most numerous in young, healthy, well-nourished women, and their number is in direct relation to their size. The best milk contains a medium number of a medium size, and the worst only a small number of a small size. The fat globules do not run together, milk being a perfect emulsion, but remain suspended in the plasma. If the milk is allowed to stand, the fat globules rise to the surface in the form of cream. The number of these globules and their size are the only indications, after the colostrum stage is passed, of the value of the milk and, apart from chemical analysis or at any rate the estimation of the specific gravity and the proportion of fat, these indications are not of much value. It is quite impossible, from a mere microscopical examination of a specimen of milk, to say whether it is of good quality and suited to the particular child.

Composition.—Human milk is a variable fluid of no constant percentage analysis. It varies in

different women, on different days, at different times of the day, at different periods of each nursing, and in the two glands. It is modified by diet, by the state of the health, by exercise, by menstruation, prolonged lactation and other causes.

In general composition it resembles the mammary secretion of other animals; the same food-stuffs are present in all, but the proportions differ considerably. These constituents are *water*, *proteids* in the form of caseinogen and lact-albumin, *carbohydrate* in the form of lactose or milk sugar, *fat*, and various *salts*. It also contains small quantities of lecithin, nuclein, cholesterin and neurin.

Other proteids have been described by various observers as present in milk, namely, peptones, lacto-globulin, whey proteid, &c. Possibly these substances owe their presence to the methods of analysis. Even if present, their quantity is so small as to warrant their being neglected in connection with our present subject. The fats consist of palmitin, stearin and olein, and a small percentage of glycerides of the fatty acids. Carter and Richmond are of the opinion that the sugar is not lactose and that two sugars are present, a crystalline aldobiose and an amorphous substance (? animal gum).

Colostrum.—The milk first secreted is very different from that of the gland when lactation is fully established. It is yellowish in colour, more alkaline in reaction, of a higher specific gravity, and contains certain bodies called *colostrum corpuscles*. These are large nucleated cells, epithelial in character, from the acini of the gland, containing granules and fat globules but not yet disintegrated. Wynter Blyth takes the view that these cells are leucocytes infiltrated with fat. The presence of the colostrum

corpuscles indicates either non-establishment or disturbance of equilibrium in the gland. They disappear more quickly from the milk of women who have had many children than from the milk of a primipara. Usually they persist for seven to ten days. They are variable in number and may be absent if the mother is feverish.

Bad health and puerperal conditions may retard their disappearance or may cause their reappearance. In many cases they reappear at the commencement of the involution of the gland, that is at about the tenth month. If they return during lactation the milk will disagree with the infant and may have to be stopped. The milk during the colostral period contains a higher percentage of proteids and salts and a lower percentage of sugar than at any other time. The amount of fat is variable and the fat globules vary greatly in size. The greater the number of colostrum corpuscles the higher is the percentage of proteid.

Colostrum is coagulable by heat and may coagulate spontaneously. Its chemical composition and the changes as it passes into normal milk are shown in the following tables:

TABLE IX.

The Composition of Colostrum.

	Pfeiffer.*	Adriance.			Edlefsen †
Proteid . . .	5·71	3·31	2·37	2·04	2·695
Fat	2·04	2·77	4·52	1·97	3·225
Sugar . . .	3·74	5·39	5·86	6·58	3·590
Salts . . .	0·28	0·27	0·26	0·24	—

* The average of five analyses during the first three days.

† Published January 1, 1901.

TABLE X.

The Alterations in Composition of Colostrum (EDLEFSEN).

Period of Lactation.	Proteid.	Casein.	Albumin.	Fat.	Sugar.
3 days	2·695	1·810	0·885	3·225	3·590
12 "	1·875	1·160	0·715	3·035	5·150
48 "	1·000	0·040	0·560	3·640	7·060
103 "	0·843	0·375	0·480	3·415	5·835
116 "	0·835	0·310	0·525	4·105	5·950

To Obtain a Sample for Analysis.—For this purpose a breast-pump must be employed. The kind most commonly in use consists of a glass bulb with an opening at the smaller end, to which a short india-rubber tube is fixed, and a lateral opening, into which is welded a piece of glass, of the size and shape of a nipple-shield. To the end of the rubber tube is attached a small piece of glass tubing or, a much better arrangement, a rubber ball-pump with its valve working backward. The latter apparatus is more suitable for the production of suction than the former which, involving the use of the mouth, ought never to be employed. Whichever form of breast-pump is used the most scrupulous cleanliness must be insisted on, both the nipple and breast and the whole apparatus being previously washed with some antiseptic solution, such as boric acid, one teaspoonful to half a pint of hot water. If the apparatus has been previously used it must be well washed in hot soda and water.

The use of the pump should cause little or no pain. Care must be taken to get a pump suitable to the individual case, and to use very gentle suction

action in drawing off the milk. With proper management and cleanliness no evil results are likely to ensue.

The sample used for analysis should be taken from the middle of the nursing, in order to obtain a fair average specimen of the whole nursing. The milk first poured out is watery and poor in fat, while that obtained at the end is rich in solids, especially fat. It is even better, if possible, to obtain the whole of the nursing, but it is curiously difficult to empty the breast with a breast-pump. The conclusions drawn from an isolated partial sample are of comparatively little value, and the great discrepancies in the analyses quoted below are partially due to this factor.

The Methods of Analysis.—A complete quantitative analysis must be made according to the methods employed in the analysis of cow's milk, described subsequently. A simple approximate clinical examination can be made according to the method of Dr. L. E. Holt, of New York, described in his work on "The Diseases of Infancy and Childhood." Holt only claims that he obtains a fairly accurate knowledge of the percentages of the different constituents and recommends the method when a more complete analysis is not available. His results are based upon the examination of a large number of specimens of milk and on the following well-known chemical facts:

(1) That the *specific gravity* of human milk varies between 1029 and 1032, the average being 1031, at 70° F. Abnormal variations occur between the limits of 1017 and 1036. An increase in the fat lowers the specific gravity; an increase in the other solids raises it.

(2) That the *salts* do not vary much in their amount in ordinary human milk. They are too insignificant in percentage to affect the specific gravity, and in the clinical examination of milk they need not be considered.

(3) That the proportion of the *sugar* is nearly constant in human milk under all circumstances. This point has been emphasised by all the chemists who have made milk analyses.

(4) That in striking contrast to this uniformity in the sugar are the wide variations met with in the *fat* and *proteid*, as is shown by the following table:

TABLE XI.

Variations in the Percentages of Fat, Proteid, and Sugar.

Observer.	No. of Analyses.	Fat.	Proteid.	Sugar.
Adriance . . .	120	1·31–7·61	0·09–3·37	5·35–7·95
Carter and Richmond	94	0·47–8·82	1·02–4·05	4·38–8·89
Chem. Lab. Coll. Phys. and Surg., N.Y. . .	29	1·12–5·02	1·10–3·62	—
Leeds . . .	43	2·11–6·89	0·85–4·86	5·40–7·92
König . . .	?	1·71–7·60	0·57–4·25	—

(5) That to determine the composition of milk we must have a knowledge of the *proportions* in which the two elements which vary most widely, namely, the *proteids* and the *fat*, are present.

(6) That from the fact that the proportion of sugar is so nearly constant, and that the salts are in such small amounts, we may for clinical purposes consider the specific gravity as modified solely by the fat and the proteids.

(7) That there is no known method of determining directly the percentage of proteids by a clinical examination, and that a complete chemical analysis by an expert is the only one that can be accepted as accurate. It is possible, however, from a knowledge of the specific gravity and the percentage of the fat, to make an approximate calculation in regard to the percentage of the proteids, at any rate sufficiently close to determine whether in a given case they are nearly normal, or in very large or small proportions.

Examination of Milk by Holt's Method.—The apparatus needed consists of a small hydrometer, graduated from 1010 to 1040, a pipette, and a glass-stoppered cylinder graduated in one hundred parts and holding about 10 c.c. The milk should be freshly pumped from the breast, and either the whole nursing or the middle milk taken; it must be handled as little as possible. Half an ounce is required for the test.

The specific gravity is taken by the hydrometer. A urinometer will do quite as well if there is enough milk.

To estimate the fat the glass cylinder is filled by means of the pipette to the upper line exactly. The cylinder is then stoppered and allowed to stand for twenty-four hours at a temperature of 66° to 72° F. Generally the lower limit of the cream becomes sharply defined in that time; if not, an additional six hours may be allowed before reading the percentage.

By comparing the percentage of cream with that of the fat, as determined by a chemical analysis of the same specimen, it has been found that the ratio

of cream to fat is very nearly 5 to 3, and for clinical purposes it may be so estimated.

The amount of proteid can then be estimated from the following table :

TABLE XII.

Clinical Examination of Human Milk (HOLT).

	Specific Gravity.	Percentage of Cream.	Proteid (calculated).
Average . . .	1031	7	1·5 per cent.
Variations—Normal	1028–1029	8–12	Normal (rich milk).
,, ,,	1032	5–6	Normal (fair milk).
,, Abnormal	Below 1028	Above 10	Normal or slightly below.
,, ,,	,, ,,	Below 5	Very low (very poor milk).
,, ,,	Above 1032	Above 10	Very high (very rich milk).
,, ,,	,, ,,	Below 5	Normal or nearly so.

Holt asserts that the conclusions drawn from this mode of examination are as exact as those obtained by the ordinary examinations of urine.

A very large number of chemical estimations of the different constituents present in human milk have been made by a considerable number of observers. One very noteworthy point about these estimations is the marked discrepancy in the results obtained by the different analysts. This variation affects both the percentage of proteids and of sugar but, as has been shown by A. V. Meigs, there is comparatively little discrepancy in the total of these two bodies. This indicates that the fault lies chiefly in the methods of analysis, whereby the proteids are separated from the milk sugar previous to the

separate estimation of each of these constituents. In many of the older analyses the percentage of proteid is too high and of sugar too low. In some instances the means used to precipitate the proteid carried down some of the sugar and the sugar was estimated by difference (*e.g.*, Simon). In others the sugar was estimated and the proteid calculated by difference (Dolan and Wood, Vernois and Becquerel). The sugar is usually estimated by the copper reduction method. This is accurate for glucose, but not necessarily accurate for the sugar in milk.

In the next table are given the results recorded by a large number of observers on the percentages of proteids and sugar.

TABLE XIII.

The Percentage of Proteids and Sugar in Human Milk.

Observer.	Proteids.	Sugar.	Total.	Remarks.
Payen	0·215	8·805	9·020	
Doyère	0·850	7·310	8·160	
Hoffman	1·030	7·030	8·060	
Meigs, A. V.	1·046	7·407	8·453	An average, from 43 women, 35 white and 8 black.
Frey	1·05	7·61	8·68	
Quévenne	1·050	7·310	8·360	
Axel Johannessen	1·100	4·670	5·770	An average from 25 women. 1895.
L'Héritier	1·300	7·800	9·100	
Adriance	1·480	6·720	8·200	An average from 120 women, 65 primiparæ, 55 multiparæ. Average age 25. 1897.
Henri and Chevallier	1·520	6·500	8·020	Method of analysis chemically unsound.
Biel	1·63–3·15	5·79–6·61		
Lehmann	1·700	6·000	7·700	

TABLE XIII.—(*continued*).

The Percentage of Proteids and Sugar in Human Milk.

Observer.	Proteids.	Sugar.	Total.	Remarks.
Kolesinsky .	1·860	5·720	7·580	
Christenn .	1·900	5·950	7·850	
Pfeiffer .	1·944	6·303	8·247	An average from 169 women. 1897.
Carter and Droop Richmond	1·97	6·59	8·56	An average of 94 analyses. 1898.
Leeds . .	1·995	6·936	8·931	An average of 80 analyses.
Kolesinsky .	2·290	5·600	7·890	
Luff . .	2·350	6·390	8·740	An average of 12 analyses.
Clemm 12th day	2·911	3·154	6·065	
Tidy . .	2·950	5·136	8·086	
Wynter Blyth	3·070	5·870	8·940	Including 0·1 per cent. of peptone.
Haidlen .	3·100	4·300	7·400	
Payen . .	3·350	3·770	7·120	
Simon . .	3·430	4·820	8·250	
Clemm . .	3·533	4·118	7·651	
Tidy . .	3·533	4·624	8·157	
Clemm 9th day	3·691	4·298	7·989	
Dolan and Wood	3·603	4·507	8·110	The best of 16 analyses.
Regnault .	3·900	4·900	8·800	
Vernois and Becquerel	3·924	4·364	8·288	Average of 89 analyses. Method unreliable. 1854.

Of the above analyses, those of Leeds, Pfeiffer, Adriance, and Carter and Droop Richmond were carried out on a large number of women and are some of the most recent. Meigs' results are also of value, the analyses having been very carefully carried out by processes which take from two to three weeks for each sample. Those of Hoffman, Axel Johannessen, Luff and Lehmann are comparatively recent.

In Meigs' analyses the age of the child suckling varied between one month and twenty-four, and the number of children the mother had had ranged from one to eighteen. The specimens of milk used for analysis were taken at different periods of lactation. The next table shows the variation, obtained by Meigs, in the percentages of the different constituents.

TABLE XIV.

The Variations in the Analyses by Meigs.

Constituents.	Lowest percentage.	Highest percentage.	Source.
Water . .	83·001	89·038	The mixed milk of 27 white women.
Proteids .	0·729	1·268	The mixed milk of 8 negro women.
Fat . .	2·412	9·045	The milk of 8 white women, analysed separately.
Sugar . .	6·996	7·704	
Ash . .	0·098	0·136	

The milk which most closely resembled his average composition was obtained from two women of the lower classes.

1. Woman, aged thirty, with a child fifteen months old.

2. Woman, aged twenty-six, with her third child, twenty months old.

It is strange that the milk at such a late period of lactation should be of average quality. Usually at this period the milk is thin and watery. Probably Meigs' results are underestimated, although he still maintains their accuracy and firmly believes that

human milk never contains more than about 1 per cent. of proteid.

Although so much prominence is given to the results obtained by Meigs, it must not be assumed that they are more accurate than those of more recent observers. Very great credit is due to him for bringing the subject before the profession more than twenty years ago. It is probable that his estimate of the proteid is too low, although some other analysts have obtained similar results.

TABLE XV.

The Most Important Average Analyses of Human Milk.

	Pfeiffer.	Leeds.	Carter and Droop Richmond.	Adriance.	Meigs.	Average.
Proteid	1·944	1·995	1·97	1·48	1·046	1·5–2·0
Fat	3·107	4·131	3·07	3·83	4·283	3·0–4·0
Sugar	6·303	6·936	6·59	6·72	7·407	6·0–7·0
Salts	0·192	0·201	0·26	0·17	0·101	0·2

The average given in the above table represents very fairly the composition of human milk. For working purposes we may make use of the higher figures, remembering always that the fluid is a very variable one. The extent of the variations in fat and proteid has been shown in Table XI. The variations in the percentage of sugar are shown in Tables XI. and XIII. Taking the results of the most reliable analyses, we may regard the percentage of sugar as varying between 5 and 8, and that it is very rarely higher or lower.

The percentage of salts varies between 0·13 and 0·37 (Leeds), 0·14 and 0·27 (Adriance), 0·17 and

0·5 (Carter and Richmond). The percentage of water varies between 83·21 and 89·08 (Leeds), 82·9 and 91·4 (Carter and Richmond).

Few chemists have estimated the proportions of caseinogen and lact-albumin separately, the two bodies being generally grouped together under the head of proteids or albuminoids. Of the results of separate estimation the following are published :

TABLE XVI.

The Relative Percentages of Caseinogen and Lact-albumin.

Observer.	Caseinogen.	Lact-albumin.
König	0·59	1·23
"	0·63	1·31
Hirt	0·63	1·50
Lehmann	1·20	0·50
Tolmatscheff	1·28	0·34
Wynter Blyth	2·40	0·57
Makris	1·8–4·8	0·7–1·7

These results are extremely unequal, although in the majority the combined proteids are about the average. Babcock and Russell (1897) state that all milks contain albumoses and peptones, and that in human milk over one-third of the total proteid consists of these substances.

Although milk may vary considerably in the percentages of its constituents, and in the combination of these different constituents, all such milk must be regarded as normal if the infant who takes it digests well and gains weight. Harrington made analyses of the milk of fourteen women whose infants were digesting well and gaining weight. The differ-

ences in composition are shown in the next table. In one case the percentage of proteid was higher than the ordinary percentage present in cow's milk, and yet the child digested the milk perfectly well. This is a very good proof that we must not condemn any specimen of human milk as unsuitable to the particular infant, unless clinical evidence shows that it cannot be digested by the child. Some infants can digest a much higher percentage of proteids than others.

TABLE XVII.

Variations in the Composition of well-digested Human Milk (HARRINGTON).

Constituents.	Lowest percentage.	Highest percentage.
Water	84·70	89·68
Solids	10·32	15·30
Proteids	1·08	4·17
Fat	2·02	5·16
Sugar	5·68	7·30
Salts	0·12	0·21

Remarks on the above Analyses.—It is evident that human milk is a very variable fluid.

The analysis of it is beset with many difficulties. The main source of error lies in the estimation of the proteids and the sugar separately. If the fat and the salts are estimated and the remaining constituents, proteid and sugar, are estimated under the head of "solids not fat," the results are fairly constant.

The proportion of fat ranges between 3 and 4 per cent. and, though in any particular case the per-

centage may be less than three, the average of 2·41, obtained by Luff from twelve analyses, appears to be underestimated. Meigs and Leeds obtained an average of over 4 per cent. from the results of the analysis of the milk of over a hundred women. Pfeiffer gives an average of over 3 per cent. from the results of 169 analyses. The average percentage of sugar may be taken to range between 6 and 7. More observations are required on the relative proportions of caseinogen and lact-albumin. So far, all that can be asserted positively is that the proteid coagulable by acid is present in cow's milk in great excess compared to the uncoagulable proteid. In human milk the relative proportions of proteid coagulable and uncoagulable by acids are different from those of cow's milk. Until we know accurately what these relative proportions are, it will be difficult, if not absolutely impossible, to prepare from cow's milk a fluid identical in composition with human milk. Even then we could not be sure that the fats are identical in the two fluids. The refractive index of butter fat, obtained by Zeiss' butyro-refractometer at 35° C., varies between 44·6 and 48·4, while that of human milk varies between 48·2 and 58·4 (Carter and Richmond).

The Salts in Milk.—The growing infant requires a considerable amount of inorganic salts for the development of its bones, teeth and other structures. The most recent analysis of the salts in human milk is that given by Rotch. With the aid of numerous assistants he collected five and a half litres of human milk. This large amount was reduced to its mineral constituents and analysed, by Harrington and Kinnicutt, with the following results:

TABLE XVIII.

The Ash of Human Milk.

Uncombined carbon	0·71
Chlorine	20·11
Sulphur	2·19
Phosphoric acid	10·73
Silica	0·70
Carbonic acid	7·97
Iron oxide and alumina	0·40
Lime	15·69
Magnesium	1·92
Potassium	24·77
Sodium	9·19
Oxygen (calculated)	6·16
	100·54

TABLE XIX.

Composition of the Ash calculated from the above Analysis.

Uncombined carbon	0·71
Calcium phosphate	25·35
Calcium silicate	1·35
Calcium sulphite	2·11
Calcium oxide	1·72
Magnesium oxide	1·91
Potassium carbonate	24·93
Potassium sulphite	8·04
Potassium chloride	12·80
Sodium chloride	23·13
Iron oxide and alumina	0·40
	102·45

The relative proportions of the salts as they occur in the milk may be calculated from the above analysis as follows :

TABLE XX.

Calcium phosphate	23·87
Calcium silicate	1·27
Calcium sulphate	2·25
Calcium carbonate	2·85
Magnesium carbonate	3·77
Potassium carbonate	23·47
Potassium sulphate	8·33
Potassium chloride	12·05
Sodium chloride	21·77
Iron oxide and alumina	0·37
	100·00

The chief differences between this analysis and all previous ones are as follows:

1. The phosphoric acid is less than half as much as previously reported.

2. The magnesium is also less than half as much.

3. Silica and alumina are present. They have not been returned in any previous analysis.

As Rotch points out, the processes employed in the analysis have been so much more exact than any previously adopted that the results are presumably correct and represent the average composition of the mineral constituents of human milk.

It is probable that neither sulphates nor carbonates exist in milk and that they are derived from the combustion of the sulphur of the proteids and carbon in organic combination (Richmond). Citric acid is also present.

Bunge's estimation of the salts in a litre of milk is as follows:

TABLE XXI.

The Salts in Human Milk (BUNGE).

	Per litre.	Per cent.
K_2O	0·78	0·078
Na_2O	0·23	0·023
CaO	0·33	0·033
MgO	0·06	0·006
Fe_2O_3	0·004	0·0004
P_2O_5	0·47	0·047
Cl	0·44	0·044
	2·314	0·2314

He also made an analysis of the ash obtained by incineration of a newly born puppy and its mother's milk, with the following results:

TABLE XXII.

	New-born Puppy.	Bitch's milk.
K_2O	11·42	14·98
Na_2O	10·64	8·80
CaO	29·52	27·24
MgO	1·82	1·54
Fe_2O_3	0·72	0·12
P_2O_5	39·42	34·22
Cl	8·35	16·90
	101·89	103·80

It is curious how closely alike are the two analyses (Table XXII.). The excess of potassium and deficiency of sodium in the mother's milk, as compared with the amounts present in the ash of the puppy, are explained by the growing animal

requiring more of the former and less of the latter. During growth the muscles develop and, as they contain much potassium, a plentiful supply of this salt is required. On the other hand, there is less need of sodium because of the replacement of the cartilage, rich in sodium, by bone. The excess of chlorine can be explained by the requirements of the digestion for hydrochloric acid and by the need of chlorides for the due activity of renal secretion.

The greatest discrepancy is in the proportion of iron. Six times as much was found in the ash of the puppy as in the ash of the mother's milk.

Bunge found in various analyses the following percentages of iron :

TABLE XXIII.

Rabbit killed directly after birth	0·120
Rabbit fourteen days old	0·044
Puppy ten hours old	0·112
Puppy three days old, from the same litter	0·096
Puppy four days old, from the same litter	0·075
Kitten four days old	0·069
Kitten nineteen days old	0·047
In the liver of a puppy just after birth	0·391
In the liver of a full-grown dog (1)	0·078
In the liver of a full-grown dog (2)	0·043

From these results it is evident that the proportion of iron in the whole organism is highest at birth and gradually diminishes with the development of the animal. The explanation of this is that the animal lays up a store, necessary for its growth, before it is born. Probably the object of this is to obviate the difficulty the organism has in assimilating compounds of iron. The excess of iron appears to be stored up mainly in the liver, which contains, in the puppy, from five to nine times as much as

that of the full-grown dog. This store of iron is obtained from the placental blood. The ash of dogs' blood contains 9·4 per cent. of iron.

Friedjung found from 3·52 to 7·21 milligrammes of iron per litre in the milk of twenty-one nursing women. The amount sank rapidly towards the end of lactation. It was increased by good health, food, and surroundings, and decreased under unfavourable conditions.

The large amount of lime salts present in the milk is due to the requirements of the young animal for considerable quantities for the purposes of bone formation.

Other constituents present in minute quantities are nuclein, an organic phosphorus compound, and cholesterin, lecithin and a yellow lipochrome. No proteoses or peptones are present in fresh milk, but the former may be found in the whey from sour milk. According to Wynter Blyth, a small quantity of peptone is present in fresh milk.

Micro-organisms in Human Milk.—Human milk is usually considered sterile, except in the case of local disease. This, no doubt, is true of the milk contained in the gland. Escherich examined the milk of twenty-five healthy women and found it absolutely devoid of micro-organisms. On the other hand, Cohn and Neumann found microbes in the milk of forty-three out of forty-eight healthy women. The varieties of organisms most commonly present were the staphylococcus pyogenes, albus and aureus, and the streptococcus pyogenes. Honigman made seventy-six examinations of the milk of sixty-four women, recently confined, and only found it sterile on four occasions. Ringel examined the milk of

twelve healthy and thirteen ill nursing women and only found it sterile in three. The staphylococcus pyogenes albus was the most common organism ; the staphylococcus pyogenes aureus was found in three and the streptococcus pyogenes in two. Staphylococci were present in the milk of eleven out of the twelve healthy women. Kostlin (1897) examined the milk and found micro-organisms in 86 per cent. of 100 pregnant women, in 91 per cent. of 137 nursing women, and in 75 per cent. of 60 new-born infants. The organisms found are usually harmless to both mother and child. The staphylococcus aureus may cause mastitis. The most common organism is the staphylococcus albus.

The microbes are most numerous in the milk first secreted and in all probability have made their way in along the ducts in the nipple. It becomes easy to understand that mammary abscesses may readily develop if unhealthy conditions arise within the breast, leading to the stagnation of the milk already secreted.

The milk last poured out of the breast is quite sterile.

In puerperal sepsis the milk may contain many micro-organisms. In tuberculosis of the breast the tubercle bacillus may be found in the milk. Possibly the latter organism may be present in the milk apart from local disease.

Such then is the composition of human milk and it is at once evident, when we consider the different constituents and the proportions of these constituents, that the mother's milk is the most perfect as well as the most natural food for the young animal. All the proximate principles of food are present, and of

these the salts are present in the proportions suitable to the needs of the growing animal. The percentage of sugar is fairly constant, that of proteids and of fat is more variable. The proportions of the two latter constituents vary under numerous conditions and it is generally found, if the infant does not make proper progress, or is subject to intestinal derangement, that it is either the fat which is deficient in quantity or, more commonly, that the proteid is in excess.

CHAPTER VII.

THE ALTERATIONS IN THE COMPOSITION OF HUMAN MILK.

HUMAN milk varies so greatly in composition that it is necessary to consider all the different causes which give rise to these variations. The variations may be divided into three main groups:

1. Alterations in quantity.
2. Alterations in quality:
   (*a*) As regards the proportion of water;
   (*b*) As regards the relative proportions of the different constituents.
3. The introduction of deleterious substances.

It has already been pointed out that in analysing a sample of milk it is of the utmost importance to obtain the whole of the milk secreted at one nursing. This is very difficult to obtain. If it be not possible, the portion known as the middle milk should be taken. The composition varies during the same nursing, so that results based on the analysis of the milk drawn at the commencement or end of the nursing will be absolutely unreliable as representing the average composition. The milk first poured out, or *fore milk*, contains more water and is very much poorer in fat than that last obtained from the gland, namely the *strippings*. The latter milk in cows is

sometimes so rich in fat that it is sold as cream. The differences in the milk at different periods of the milking are shown in the following tables for the woman, the cow, and the ass. No doubt the same holds good in the mammary secretion of other animals.

TABLE XXIV.

Human Milk, before and after Suckling (Carter and Richmond).

	Proteid.	Fat.	Sugar.	Salts.	Total solids.	Water.
Before suckling	1·99	2·89	6·51	0·28	11·67	88·33
After suckling .	1·99	3·18	6·53	0·26	11·96	88·04

Johannessen found that during one nursing the proteid percentage remained about the same, the sugar diminished a little, but the fat increased from 2·77 to 3·94.

TABLE XXV.

Percentage of Fat and Proteid in Human Milk (Forster).

	Proteid.	Fat.
Fore milk . . .	1·13	1·71
Middle milk . . .	0·94	2·77
Strippings . . .	0·71	5·51

Reiset obtained small portions of human milk immediately before and after the child was put to the breast. On estimating the total solids he found :

TABLE XXVI.

Total Solids in Human Milk (REISET).

Case.	Before Suckling.	After Suckling.
1	10·58	12·93
2	12·78	15·52
3	13·46	14·57

TABLE XXVII.

The Percentage Composition of Cow's Milk at Different Stages of the Milking (HARRINGTON).

	Water.	Solids.	Fat.	Salts.
Fore milk . .	86·66	13·34	3·88	0·85
Middle milk . .	84·60	15·40	6·74	0·81
Strippings . .	82·87	17·13	8·12	0·82

TABLE XXVIII.

The Difference between Fore Milk and Strippings (WYNTER BLYTH).

	Devon Cow.		Guernsey Cow.	
	Fore Milk.	Strippings.	Fore Milk.	Strippings.
Water	90·319	83·940	88·400	83·394
Solids	9·681	16·060	11·600	16·604
Proteids . .	4·598	5·824	5·426	4·451
Casein . .	2·387	4·304	4·708	3·435
Albumin . .	1·830	0·975	0·451	0·860
Peptones . .	0·381	0·545	0·267	0·156
Fat . . .	1·166	5·810	0·357	5·946
Sugar . .	3·120	3·531	4·943	5·280
Salts . . .	0·797	0·895	0·874	0·929
Specific gravity .	1·0288	1·0256	1·040	1·023

Peligot had an ass milked in three successive portions, and obtained the following results:

TABLE XXIX.

Peligot's Analyses of Ass's Milk.

	Proteid.	Fat.	Sugar.
Fore milk . . .	1·76	0·96	6·50
Middle milk . .	1·95	1·02	6·48
Strippings . . .	2·95	1·52	6·50

Harrington's results show a marked increase in the amount of fat in cow's milk as the milking progresses. Wynter Blyth's two analyses show an even larger relative increase. Peligot's results show a similar increase in the amount of fat, and also of the proteid in ass's milk. Judging by analogy from these results human milk will present like differences; it will be richer in fat at the end of the nursing, and at the beginning will contain less fat and total solids, and more water. The few observations recorded show an increase in the proportion of fat. The increase is extremely variable in amount. Reiset's analyses show that the percentage of total solids is greater at the end than at the beginning of the nursing.

Alterations in Quantity.—The normal amount secreted daily is usually between 700 c.c. and 800 c.c., equal to 24 to 28 ounces, or between a pint and a pint and a half. This amount is often exceeded and the mother may secrete over a litre. To estimate the amount taken at each nursing weigh the child immediately before it is put to the

breast, and again as soon as it has finished suckling. The difference in weight represents the weight of the milk taken. According to Meigs and Scott this method is untrustworthy. Their experiments gave returns of from 80 to 100 per cent. of the amount taken. From the result the total daily amount can roughly be estimated by multiplying the weight of the feed by the number of feeds in the twenty-four hours. This estimate must not be regarded as an accurate one, as it by no means follows that the amount of milk obtained by the child at each nursing is the same. To obtain accurate results the amounts taken at each nursing should be estimated for one or more periods of twenty-four hours. The daily secretion of milk increases, up to certain limits, with the duration of suckling and the vigour of the child, in order to supply the wants of the growing body. The breast is, to a large extent, a self-regulating mechanism; it will secrete more milk if more is required, and less if the demands upon it are small. A similar result holds good in the case of cows. If the udder is incompletely emptied by a bad milker the cow secretes less and less milk daily.

The quantity is of little value as an indication of the quality. An abundant or scanty supply may be either rich or poor.

Careful weighing of the baby, before and after feeding, was carried out over a long period by Haehner in three cases, and by Laure and Ahlfeld in one each. From their results we can estimate roughly the daily quantity as:

At the end of the	1st week	.	300–450 c.c. (10–15 oz.)
,, ,, ,,	2nd ,,	.	400–550 ,, (13–18 oz.)

At the end of the 3rd week	.	500–650 c.c. (17–22 oz.)
,, ,, ,, 4th ,,	.	600–750 ,, (20–25 oz.)
During the 2nd month	.	600–900 ,, (20–30 oz.)
From the 3rd to 6th month	.	700–1000 ,, (23–33 oz.)
,, ,, 6th ,, 9th ,,	.	800–1200 ,, (27–40 oz.)

The quantity increases rapidly up to the end of the second month and then much more slowly. The limits given are wide, but so too are the limits of babies in size and appetite, and of mothers in milk-secreting powers. During the first two or three months large babies take from 15–20 per cent., and small babies 10–15 per cent. of their weight in milk. After that the proportions are smaller.

The quantity can be *increased* by various methods:

1. The ingestion of an increased amount of fluid. It is advisable that the fluid should be nutritious in quality, such as milk, gruel, cocoa, chocolate, animal broths, &c. It is also increased by the moderate use of stimulants, such as ale or porter, white wines, burgundy, or port.

2. By improving the general health and nutrition, as by tonics, or by extra food. Somatose is sometimes useful in increasing or maintaining the flow.

3. By galactagogues; that is by drugs which directly influence the secretion of milk. Pilocarpin is the drug chiefly employed for this purpose. It was first recommended by Ringer in 1875. If the diminished secretion of milk has come on suddenly, two or three subcutaneous injections of one-sixth of a grain of the nitrate of pilocarpin on successive days may be sufficient to restore it. If the diminished secretion has continued for some time, as many as ten or twelve

injections may be required. No ill effects have been noted as resulting to mother or child from the treatment. The dose must be sufficient to produce some heat of the skin of the face or body.

Grinewitch (1897) recommends drachm doses of a tincture of the common goat's rue (Galega officinalis) five times a day, or a tincture of the stinging nettle in doses of one-half to one ounce. He states that the quantity is increased without injury to the quality.

Thyroid extract, grs. iij–v, is also sometimes used.

4. By electricity.—Aubert and Pierron have recorded cases where in suspended lactation a copious secretion has been produced by faradisation of the breasts. The current should not be strong enough to cause contraction of the pectoral muscles or pain, and may be applied for five minutes daily. It may be applied by the ordinary sponge electrodes moistened with salt solution, or by means of a special spherical copper cap accurately fitted to the breast.

5. By massage of the breasts.—The massage may be used for ten minutes at a time, three times a day. A mild antiseptic ointment should be applied to the breasts and nipples and to the hands of the masseuse. Massage of the abdomen in an upward direction may be also tried.

6. By frequent suckling.—Constant application of the child to the breast will sometimes lead to the secretion of a sufficient quantity of milk for the nutrition of the child. This applies also to women whose breasts are secreting no milk or have temporarily stopped secretion. The breasts of some

women will secrete actively while the child is suckling, only a small amount of milk being formed in the intervening periods.

The quantity of milk secreted may be *diminished* by reducing the amount of liquids in the diet and by the internal administration of saline cathartics, such as Epsom salts or effervescing citrate of magnesia. Sometimes a full dose will entirely stop the secretion for a time, so such drugs must be used with care and moderation in the treatment of constipation during the period of lactation. For the sake of the child it is rarely necessary to diminish the quantity of the milk. If the milk is too poor in quality it is better to try and improve it by measures which will lead to an increased secretion of solids, rather than by measures which diminish the amount of water.

Preparations of belladonna or atropine, taken internally or applied locally, are of very great value in lessening the secretion. Camphor in pills, grs. iij–v, three times a day for three days, may completely arrest secretion. According to Stumpf potassium iodide lessens the secretion in animals and human beings. The decrease involves all the constituents, not the water only, and the breasts may atrophy. Usually this drug in small doses has no effect at all on the secretion. All these measures are of special service when the infant is weaned suddenly and the breasts consequently become tense and painful.

Complete agalactia may result from fright or sudden shock. Sorrow, passion, great excitement, or nerve exhaustion from any cause may affect the supply. The common effect is a diminution in

quantity and an alteration in quality. Possibly toxic products, from imperfect elaboration of proteids, are formed and the child is upset.

Effect of Age.—The milk of women of different ages varies a little in composition. Such variation is not greater than is found in the milk of any individual woman at different periods of lactation, and with varying diet. According to Kolesinsky the percentage of proteid in the milk diminishes with the increase in the age of the mother.

TABLE XXX.

Variation in Percentage of Proteid according to Age (KOLESINSKY).

Age in years .	20–25 ...	25–30 ...	30–35 ...	35–40
Proteid . .	2·32 ...	2·09 ...	2·03 ...	1·95

Such a table as this is of no practical value, unless it were based on a very large number of analyses of the whole milk of one nursing taken at the same time of the day in each case, and from healthy women living under the same conditions of diet and surroundings. Even if we suppose these observations correct, they do not indicate that increasing age has a serious or even important effect upon the percentage of proteid. Further analyses are required to prove whether increasing age has any effect upon the percentage of fat. Johannessen found the largest amount of fat in milk of women between 20 and 25; of proteid between 25 and 30; of sugar above 30 years of age.

Effect of Menstruation.—Sometimes the return of the catamenia causes an alteration in the milk of such a nature as to make it disagree with the child and give rise to indigestion and diarrhœa.

Occasionally the infant is seriously affected. As a rule, a slight disturbance of digestion is all that results. Meyer noted disturbance in the infants in one half of 685 cases. Pfeiffer and Schlichter consider such disturbances exceptional. Usually no alteration in the quality of the milk is produced, at least so far as can be judged from its effects upon the infant.

According to Vernois and Becquerel, the milk becomes poorer in lactose and richer in casein and fat. Rotch, on the other hand, found that the fat was diminished considerably, and the lactose slightly. He agreed with the other observers that the percentage of proteid is increased.

TABLE XXXI.

Effect of Menstruation on Milk (ROTCH).

	Catamenial milk, second day. Child's bowels loose.	Milk seven days after menstruation. Bowels regular.	Milk forty days after menstruation. Gaining weight.
Water . .	89·60	89·16	89·79
Solids . .	10·40	10·84	10·21
Proteid .	2·78	2·12	0·98
Fat . .	1·37	2·02	2·74
Sugar .	6·10	6·55	6·35
Salts . .	0·15	0·15	0·14

In 1890 F. Schlichter recorded the following results of observations on fifty-two children suckled by menstruating women. In thirty-three cases an analysis of the milk was made and showed less difference in composition than is found in milk from the same individual at morn, noon, and evening.

TABLE XXXII.

Alterations in the Milk of Menstruating Women. Average of Thirty-three Analyses (SCHLICHTER).

Casein	0·05 per cent.	increase
Fat	0·24 ,,	,,
Albumin	0·03 ,,	decrease
Lactose	0·09 ,,	,,
Dry substances . . .	0·12 ,,	,,

Schlichter's conclusions:

1. The return of the menses during lactation, after the sixth week from delivery, is not necessarily injurious to mother or child.

2. Colic, dyspepsia, and enteric catarrh should be regarded as coincidences, and should be treated in the usual way by regulation of the nursings and intervals, and by medication. A change of nurse or artificial alimentation is not required.

3. Metrorrhagia in the mother may retard the development of the infant.

4. Only one child became dyspeptic, and this did not interfere with the normal gain in weight. In some cases the increase in weight was extraordinary. The average increase was greater during and after than before the period. The condition of the child remained all that could be desired.

Monti in 1892 recorded his observations to the effect that no constant influence is induced by menstruation on the percentage of fat and the specific gravity. In some cases the proportion of fat was temporarily increased.

Supposing Rotch's analyses are correct, the explanation of any digestive disturbance, caused by the milk secreted during the menstrual period, lies in the excess of proteid. A diminution in the amount of

fat is not likely to give rise to such disturbance. Considering how common it is for babies to continue suckling during the mother's menstrual period, it may be laid down as a general rule that the onset of the catamenia is no bar to the continuance of breast-feeding. In cases where the milk does markedly disagree it is advisable to have an analysis made and, if it be found that the percentage of proteid is decidedly increased, steps must be taken to modify it, as by increasing the intervals between the nursings or by the administration of a certain quantity of water or barley-water to the child, just before feeding it, or by alterations in the diet or mode of life of the mother. It is rarely necessary to wean the child, except perhaps in the few cases where every catamenial period is the cause of acute gastro-enteric disturbance in the child. The menses may return once comparatively soon after delivery and then remain absent for many months.

Effect of Pregnancy.—Should the mother become again pregnant during the period of lactation it is an important question as to whether the suckling infant should be weaned or not. In many cases there is no doubt that weaning is essential for the sake of the mother, and can be advised without detriment to the child. A great many women have not sufficient physical and constitutional strength to provide nutriment for the growing child and the unborn infant. In deciding the question we must consider:

1. The health of the mother.
2. The condition of the child. Is it gaining weight at the proper rate, and does the supply of milk satisfy its hunger?

3. The composition of the milk.
4. The time of the year.
5. The age of the suckling child and the time the next confinement is expected.

Supposing the child is gaining weight and is contented and the mother's health is not suffering, then suckling may be prolonged to the fifth or even the sixth month of pregnancy. Partial weaning should be begun not later than the sixth month, and the child should be completely weaned by the end of that month. As a rule, it will be found necessary to wean at a much earlier date. If the babe is delicate or the weather is hot, it is advisable to continue suckling as long as possible. If, on the other hand, the mother is delicate or the milk-supply insufficient, partial weaning may be begun at the end of the fourth month.

There is a slight risk of reflex miscarriage being set up by suckling. This risk is so small that, except in the case of women who are very prone to miscarry, it need not be seriously considered.

The number of pregnancies does not affect the milk-supply as long as the general health of the mother is not impaired.

Effect of Food.—In the chapter on the physiology of lactation it was shown that the nature of the food exercised a marked influence on the quantity and the quality of the milk. This is especially the case with regard to the percentage of fat in the milk, the proportion increasing with the amount of proteid food taken. From this it is evident that, if the milk be poor in fat, the proper way to remedy the defect is to increase the proteid and diminish the fatty food taken by

the mother. Vegetable diet diminishes the amount of fat and proteid. Malt extracts raise the quantity and the percentage of fat. Too much fat in the milk may be injurious to the child, and it may be due to this cause that the milk of wet-nurses disagrees. A wet-nurse is usually obtained from a class of people unaccustomed to high living and a large amount of proteid food. Consequently the unlimited diet, including a large quantity of meat and frequently stimulants, leads to the secretion of unsuitable milk and often to gastric disturbance from the over-feeding and insufficient exercise combined.

Effect of Exercise.—Increase in the proteid diet not only leads to an increased secretion of fat but also to an increase in the amount of proteid in the milk. Hence the milk may be rendered much richer in quality but more indigestible by virtue of the proteid it contains. To a large extent this difficulty can be overcome by ordering that increased nitrogenous diet must be supplemented by an increase in the daily exercise taken. To convert a poor milk into a digestible rich one, order the mother to take three meat meals a day and walking exercise to the extent of at least a mile every morning and afternoon. Sometimes more severe exercise is necessary. In such cases a moderate amount of riding, cycling, or lawn tennis may be recommended. Among the lower classes household work is a fair remedy, but open-air exercise is of more advantage, if the mother can be induced to take it. If on analysis the milk is found rich in proteid to such an extent as to give rise to colic and indigestion in the child, and that the other constituents are suitable in amount, the percentage of proteid may be partially reduced by

exercise and, if this is found an insufficient remedy, the milk may be diluted by giving the child, before it is put to the breast, a small quantity of barley water or plain boiled water. The presence of curds in the stools is a very good indication of the indigestible quality of milk containing an excess of proteid.

So far we know of no means for modifying the amount of sugar. As the percentage of this constituent varies within only small limits, and is rarely if ever insufficient, it may practically remain unconsidered.

Effect of Fasting.—A nursing mother must not fast. Not only is a deficiency of food bad for her but it is still worse for the child. The milk is rendered insufficiently nutritious and the mother has to draw on her reserve stores of nutriment to provide even this imperfect diet. Kolesinsky examined the milk of five women, on ordinary diet and on a diet devoid of meat, milk, eggs and butter.

TABLE XXXIII.

Effect of Fasting on the Milk (KOLESINSKY).

	Ordinary diet.	Fasting diet.
Specific gravity . .	1028	1031
Proteids	2·29	1·86
Fat	5·17	3·41
Sugar	5·60	5·72

A nutritious diet, mixed in kind and containing a moderate excess of proteid, is required from the commencement of lactation; not a low diet in the early period, as was formerly recommended.

Effect of Irregularity in Nursing and Alteration in the Length of the Intervals between each Feed.—Increasing the frequency with which the breast is given causes an increase in the percentage of solids in the milk, especially proteids. A large amount of unnecessary suffering endured by infants is due to colic caused by indigestible milk, milk too rich in proteid. Both the mother and the infant soon learn that the ingestion of a warm fluid, such as breast milk, relieves the pain for a time. They are not equally quick at learning that such relief is purely temporary and is again followed by pain, even worse than before. Hence the mother acquires the habit of giving the child the breast whenever it cries, on the assumption that the child is crying from hunger. The more frequent the feeding the more indigestible the milk becomes, the gland being stimulated to excessive metabolism, with increased secretion of proteid. This is shown to be the case in animals, namely, the cow and ass, by the analyses of Reiset and Peligot.

TABLE XXXIV.

Cow's Milk (Reiset).

Interval since last milking.	Percentage of total solids.	
	At the beginning.	At the end.
12 hours . .	9·33	16·04
6 " . .	12·80	16·06
2½ " . .	12·84	13·08

Klimmer found that in cows shortening the interval between the milkings caused an increase in

the fat and dry residue. He suggests fractional milking as a means of obtaining a special percentage of fat.

TABLE XXXV.

Ass's Milk (PELIGOT).

Interval since last milking.	Proteid.	Fat.	Sugar.
24 hours . . .	1·01	1·23	6·33
6 ,, ...	1·55	1·40	6·40
1½ ,, ...	3·46	1·55	6·65

Therefore, by analogy, in women the more frequent the nursing the greater is the amount of proteid in the milk and the more marked is the colic and indigestion in the infant. Such cases are usually relieved very quickly by lengthening the intervals between the nursings and by giving hot water, one to four tea-spoonfuls, when the attacks of pain occur. Sometimes carminatives are required. If simple treatment of this nature does not afford relief and analysis of the milk or the character of the stools shows an excess of proteid, attempts must be made to diminish the amount of proteid by increasing the exercise, alteration in diet, and other means previously referred to.

The Means of Regulating the Composition of the Milk.—The various means at our disposal may be summed up in the form of a table for ready reference. It must be remembered that the percentages of sugar and salts are very constant, and that the changes we have to deal with are in the percentages of proteids and fat.

TABLE XXXVI.

The Methods for Altering the Composition of Human Milk.

The percentage of proteid is *increased* by—
Increased frequency of nursing,
Increased proteid food,
Insufficient exercise.

" " *diminished* by—
Diminished frequency of suckling,
Decreased proteid food,
Increased exercise.

The percentage of fat is *increased* by—
Increased proteid diet,
Malt extracts.

" " *diminished* by—
Deficiency of proteid food,
Excess of fatty foods,
Fasting.

The percentage of water is *increased* by—
Increased fluid diet.

" " *diminished* by—
Diminished fluid diet,
Saline cathartics.

The Effect of Alcohol.—Alcohol influences lactation by its effect on metabolic activity. It is said to increase the proportion of fat, slightly to diminish the amount of sugar, and to have no constant effect on the proteid. Many nursing women take a moderate quantity, in the shape of malt liquors or wine, without injury to the babe and with distinct advantage to themselves. Certain observations have been made as to the presence of alcohol in the milk when taken by the mouth. R. Demme in 1891 found alcohol in the milk of a woman who was in the habit of drinking to excess. It was not found in the milk of a goat by Lewald and Stumpf when given in the food. Binz found that when 25 c.c. of alcohol, diluted with 50 c.c. of water,

were given to a goat, no trace of it could be found in the milk; when 100 c.c. of alcohol, diluted with 200 c.c. of water, were given and the animal intoxicated, 0·3 per cent. of alcohol was found in the milk.

Klingemann carried out two experiments:

1. Two women took each 375 c.c. of sparkling wine, containing 12 per cent. alcohol.

2. Two women took each 320 c.c. of port, containing 18 per cent. alcohol.

No appreciable amount of alcohol was found in the milk in either experiment.

According to Stumpf, the addition of alcohol to the food does not increase the amount of milk but raises the percentage of fat.

These experiments indicate that moderate quantities of alcohol can be taken by the nursing-mother without any alcohol appearing in the milk. Clinical experience supports the view that alcohol in moderation is not injurious. On the other hand, excess may lead to considerable alteration in the quality of the milk and a fatal illness of the child.

Put shortly, the indications for and against the use of alcoholic drinks by the nursing-mother may be summed up as follows:

In moderation, the use of alcoholic drinks has no deleterious effect on the milk or through it on the child.

A woman who is unaccustomed to the use of such drinks does not require them necessarily, merely because she is nursing. Many such women can rear their infants quite successfully without the aid of stimulants. In such cases alcoholic drinks must be regarded in the light of medicines and prescribed in accordance with the nature of the case. A

delicate woman may require the addition of some stimulant to her ordinary diet, and no woman is justified in sacrificing her child to her teetotal principles. If, on careful investigation of the particular case, it is found that the mother's strength and health are not able to support the fatigues of nursing and the supply of a suitable milk in sufficient quantity for the infant, and that the addition of light ale, stout, or some kind of wine, will enable her to continue nursing, such treatment must be insisted on rather than allow the child to be weaned.

The effect of alcohol is partly to increase the quantity of the milk and partly to increase the proportion of fat in it. The latter effect is perhaps of greater consequence than the former, which is mainly due to the amount of fluid. Thus, if it is found on examination that the milk is too poor in fat, the addition of alcohol is often of decided advantage. It has been previously shown that the best method of increasing the fat in the milk is by increasing the amount of proteid food taken, but this has the disadvantage of also increasing the percentage of proteid in the milk. The addition of a small quantity of malt liquor appears to increase the amount of fat and not the proportion of proteid. Such drinks must not be relied on to provide a good milk. Good milk depends on good and suitable food and not upon stimulants. To insist on the prolongation of nursing when it can only be continued by the means of a considerable amount of stimulation is bad for both the mother and the child.

That harm sometimes results to the child from the use of stimulants by the mother is well recog-

nised. This is due to the amount of stimulant taken or to the kind employed. Thus I have come across many cases of infantile dyspepsia and diarrhœa due to the mother taking three, four, or more half-pints of ale, stout, &c., daily, and readily cured by reducing the amount to one half-pint a day. Needless to say, the stimulant is often taken in place of the more useful and nutritious food. Gastric troubles are set up in the mother and the milk-supply is still further impaired. Sometimes the stimulant is not fresh, has undergone acetic acid fermentation, is "hard," and may therefore be injurious through the by-products it contains.

The amount taken should never exceed one pint of malt liquor or two glasses of port, burgundy, or champagne daily. In the majority of cases one glass of wine or half a pint of malt liquor is sufficient. It should be taken at meal-times and not on any account between meals and, if only the smaller amount is prescribed, it should be taken with the mid-day meal. No stimulants should be allowed at bedtime. Chocolate, gruel, or milk is much more suitable and valuable at that time.

Of course there is a slight risk of setting up the alcoholic habit by prescribing stimulants for women unaccustomed to them, but the risk is small if the stimulant is only given at meal-times and in small quantities. It should be discontinued if the mother's strength improves to such an extent that she can do without it.

The two indications for the use of alcohol are the health of the mother and the quantity of the milk. A delicate woman, or one who has been accustomed to alcoholic drinks, will require a certain amount; a

healthy woman, who has not been so accustomed and has an efficient milk-supply, does not require it. Too much stress cannot be laid on the fact that a woman does not need stimulants merely because she is nursing and that each case should be judged on its merits. At present the custom is for the physician to recommend stimulants, if he has not been forestalled by the patient's relations or friends, for any and every defect in the secretion of milk or the health of the mother.

The Introduction of Deleterious Compounds.—Certain drugs given by the mouth to the mother are partially excreted in the milk and, through this channel, affect the child. This is more likely to occur when the milk is of poor quality. Some drugs thus excreted exert no injurious influence and may even be beneficial. It is perfectly useless to attempt the administration of drugs to the infant through the medium of the milk-supply. The excretion of drugs in the milk is unreliable and uncertain in amount. Drugs are also given to the mother to modify the quality of the milk or to treat some illness. Various kinds of vegetables, fish, and other articles of food may, when taken by the mother, cause the excretion in the milk of products poisonous in their effect on the babe.

Citric acid and **hydrochloric acid** produce no change in the mother's milk. The mother need not be deprived of acid foods and drinks. **Sodium salicylate** given in doses of fifteen to thirty grains to the mother can be discovered in the urine of the child, if it has been nursed an hour or more after the dose was administered. When the child was nursed soon after the dose was taken the salicylic

reaction was not found in its urine (Schling). According to Fehling, this drug greatly increases the secretion of milk which, after a dose of thirty grains, becomes dangerous to the child. I have given the drug, in doses of fifteen grains three times a day, to nursing-mothers without the least sign of any injurious influence on the child. It may lessen the percentage of fat and sugar.

Potassium Iodide passes readily into the milk, though it does not appear for some time after its administration. It is found in the milk for twenty-four hours after taking the drug. It can also be detected in the urine of the child. Three to five grains may be given three times a day to the mother without any ill effect upon the child. Iodism has been reported in nursing infants.

Potassium Ferrocyanide, given in doses of thirty grains, can be detected in the mother's urine, but not in that of the child.

Iodoform applied externally to the mother may be found in the urine of the child in the form of iodine, in three to four days. It passes very readily into the milk and may be found in the child's urine before it is detected in the mother's. It does not cause any injury to the child. The child's navel may be dressed with it without bad effect. According to Schling, after prolonged application of this drug to the vagina and vulva of the mother it was found in the mother's milk and urine, but not in the urine of the child.

Iodine injected intra-muscularly (5 per cent. solution in Oleum Amygdalæ) is secreted in the milk as a soluble albuminous compound. The proteid is increased while the fat and sugar are decreased.

Mercury may be transmitted through the milk to the child, but only feebly, irregularly, and after a long interval. **Lead, Arsenic, Antimony, Bismuth,** and many other drugs have been excreted in the milk. Macé states that arsenic passes very readily into the milk. **Quinine,** taken on an empty stomach, may affect a young infant. **Rhubarb, Senna,** and **Saline Cathartics** may pass into the milk and purge the child.

Colchicum.—An epidemic of gastro-enteritis, occurring in Rome in 1875, was found by F. Ratti to be due to the milk of goats which occupied pastures containing the Colchicum autumnale. He found colchicine in milk.

Morphia in therapeutic doses is eliminated as apomorphine in the milk of the mother (Pinzani). One-half to one grain of morphine was administered to wet-nurses in twenty-four hours without any perceptible effect on the infant, and no morphine was detected in the milk (Pinzani). The accuracy of these statements has been called in question by Fubini, Cantu and Fürst. According to Fehling, long and deep sleep in the infant sometimes follows the administration of morphine to the mother. It does not prove that such sleep is unnatural.

Small doses of morphia administered subcutaneously to the mother seldom affect the child. The liquor morphinæ hydrochloratis given by the stomach to the mother in small doses has no bad effect on the child.

Tincture of Opium taken by the mother in doses of fifteen to thirty minims produces neither sleep nor constipation in the child. Thornhill has, however, noticed prolonged sleep in the infant. On

the whole, apart from other considerations, opiates should be given to nursing women with great caution.

Atropine passes readily into the milk. So, too, belladonna in full doses. Subcutaneous injections of a half to one minim of a 1 per cent. solution caused pronounced symptoms in the mother and dilated pupils in the child. The dilatation disappeared after twenty-four hours (Schling).

Chloral hydrate may cause prolonged sleep in the infant. The effect of **Bromides** is variable. Antipyrin and phenacetin may appear in the milk.

CHAPTER VIII.

THE CONTRA-INDICATIONS TO BREAST-FEEDING. THE METHODS OF WEANING.

The chief conditions indicating that a mother is not fitted to suckle her child are mainly those of general or local malaise. Sometimes, in spite of the physical health of the mother being perfect, the child does not thrive. The failure may be due to the milk being insufficient in quantity or deficient in quality, or over-rich in solid constituents, or because the breast is not given at proper intervals and in a suitable manner. These latter conditions can be remedied by appropriate means, and do not warrant the assumption that the mother must wean the infant. Far too many infants are weaned on slight and easily remedied grounds. Sometimes there is complete agalactia.

All these factors must be duly considered and weighed before deciding that the mother is unfitted to suckle her child.

The General Health of the Mother.—The most important constitutional affections to consider in this relationship are tuberculosis, syphilis, and a neurotic predisposition. The importance of prophylaxis, in reference to these conditions especially,

should be recognised long before the birth of the child and even before conception. It cannot be expected that a woman unsound in body or mind will have healthy children. Women with tuberculous disease do not secrete good milk; still it happens that a good many affected with this disease bring up their children at the breast satisfactorily. If there is active mischief going on in the lung, suckling should be absolutely prohibited. Even if there is no active mischief it is advisable, in the presence of a marked family history of tuberculous affections, or of a past history pointing to lung trouble, that the child should be reared artificially, both for its own sake and still more for the sake of the mother. The wear and tear of suckling, especially when long continued, may develop a latent tuberculosis.

If there is actively progressing mischief, a certain amount of danger of transmission of the tubercle bacillus through the medium of the milk is incurred. Thus Stiegenberger in 1890 reported a case of caseating tuberculous glands in an infant five months old, who had been nursed for a month by a woman with active pulmonary phthisis, the child's parents being perfectly healthy. It is possible that the infective bacillus reached the child through the milk. On the other hand it is more probable that infection took place through the respiratory tract from the inhalation of dried particles of sputa. Boyer and Garnier in 1900 reported the case of an infant, healthy at birth, who died of marasmus at six months with tuberculous disease in the mesenteric glands, liver, spleen and kidneys. The mother died seventeen days after confinement from advanced phthisis of the lungs and had tuberculous

disease of the breast. She had nursed her infant for some days. I am unaware of any observations demonstrating the presence of the tubercle bacillus in the milk of a tuberculous woman, whose mammary glands are not diseased.

The existence of any evidence of past tuberculous disease of glands or bone is not sufficient to contra-indicate breast-feeding. In such cases both the child and mother must be carefully watched. Weighing the child every week will show whether it is thriving properly and, as long as it does thrive and the general health of the mother is maintained, breast-feeding may be continued up to the usual time of weaning.

Deficient progress on the part of the child, the mother being apparently in good health, may be due to deficient quantity or quality of the milk and may be remedied by a little supplementary feeding. In this, as in all other cases, weaning must not be advised hastily and without carefully weighing all the factors in the particular infant.

Constitutional syphilis frequently affects the milk-supply to such an extent as to render it insufficiently nutritious. Many women affected with this disease rear their infants on the breast successfully, especially in those cases where the mother presents no evidence of the disease, although the child may be considerably affected. If the child is brought up at the breast the best indication of proper progress is the weekly gain in weight, and this should be carefully watched. It is almost needless to add that in cases of this nature the choice lies between artificial rearing and feeding at the mother's breast. The employment of a wet nurse is quite out of the

question in the present uncertainty of our knowledge as to the infectivity of congenital syphilis. My own experience is that the infectivity of the disease in this stage is grossly exaggerated. Among many nurse children affected with the disease and brought up without any precautions as to the spread of the infection to the nurse, who has often given the child as much care and attention as if it were her own, I have not come across one single case of the disease in the nurse due to infection by this means.

A neurotic inheritance has a bad influence in a variety of ways. The insanity of lactation is especially liable to develop if there is a family history of insanity. With such a predisposition prolonged lactation may give rise to hypochondriasis or melancholia. A mother liable to epileptic fits might injure her child should a fit occur. The case is recorded of a suckling woman, aged twenty-eight, in whom an epileptic fit caused an abundant flow of milk. After the attack the lacteal secretion remained absent. Besides these results, which cannot be regarded as common, it is frequently found that the emotional temperament, so often associated with a neurotic inheritance, affects both the quantity and the quality of the milk, and the infant gets a supply which may be deficient in quantity or indigestible in quality. Such women are prone to emotional excitement on slight provocation, with the result that the milk secretion is affected. Mere nervousness will increase the percentage of proteid in the milk.

General debility is a common cause of inability to nurse successfully. It may be due to the mode of

life, bad hygienic surroundings, insufficient food, mental worry or distress, or to too frequent pregnancies. The educational pressure at girls' schools is an unsuitable preparation for the functions of motherhood. Physical development and exercise, on the same lines as are unanimously approved of for boys, will improve the bodily and nervous health of the girl and enable her to discharge the maternal duties successfully. Albuminuria in the mother is not *per se* a bar to successful nursing. The child will probably thrive and the mother make favourable progress.

Any acute disease, more especially if belonging to the group of specific fevers or any form of pyæmia or septicæmia, renders immediate weaning essential. Sometimes in such cases the secretion of milk is abruptly stopped. Erysipelas and puerperal fevers come under this grouping.

Nursing women sometimes suffer from rheumatic pains, so severe and constant as to merit the name of the "rheumatism of lactation." As a rule these pains can be cured by a more nutritious diet and tonics, but if they do not yield to such treatment the child should be wholly or partially weaned. Gouty women are usually unsatisfactory mothers.

Lactation is a physiological process and cannot be considered a serious drain on the system, if the food-supply is satisfactory and the functions of nutrition are perfectly carried on. It is important, therefore, not to recommend weaning carelessly and unnecessarily, as is so often done. Much can be done to enable the mother to suckle her child satisfactorily, by regulating the manner of living and ordering a sufficient supply of nutritious food, stimulants and

tonics. Careful regulation of the frequency of feeding, &c., is also essential. Sometimes, in spite of such treatment, the mother continues to lose flesh and strength and weaning becomes essential for the sake of her health. In doubtful cases nursing may be tried if the effect on both mother and child is carefully noted.

Local Conditions of Ill-health.—A painful affection of the nipples, namely fissure, may be induced by various causes and may be so severe as to render suckling impossible. Fissure is usually preceded by abrasion or excoriation, due to want of cleanliness, to constant moisture from galactorrhœa, to too frequent suckling, or to the hardening astringent lotions sometimes recommended as preventives. Infection of the raw surface, combined with the mechanical effect of suckling, prevents healing. It is most likely to occur in primiparæ and in those with short or depressed nipples. An attempt should be made to prevent its occurrence by bathing with cold water before and after nursing, and by treating with zinc ointment any excoriation which may develop. If a fissure has actually formed, the use of a nipple shield may enable the mother to continue suckling until it has healed. After nursing the shield must be well washed in a solution of boric acid, a heaped teaspoonful to a pint of boiling water, and then kept in a cold solution of similar strength. The nipple should be dried with antiseptic cotton wool and a mucilaginous lotion of boric acid, twenty grains to an ounce of mucilage, painted over the surface freely with a camel's hair brush. If this fails to cure, touch the fissure every other day with a finely pointed stick of nitrate of silver.

For the relief of pain a 5 to 10 per cent. solution of cocaine may be applied half an hour before nursing, but the mother must remember to wash the nipple before allowing the child to suck.

None of these remedies may be efficacious, and the fissure gets deeper and bleeds freely at each nursing. If this be so, that breast must be withheld entirely and the child fed alternately on the other breast and an artificial mixture. During the period of enforced rest an attempt may be made to maintain the physiological activity of the gland by the systematic use of the breast pump. If both nipples are affected the child must be entirely weaned and a similar attempt made to maintain the activity of the glands until the fissures are healed.

In slight cases the mother may be able to continue suckling by means of the nipple shield. Occasionally a child refuses to suck through a nipple shield. If it does, fill the shield and moisten the external surface with warm milk, invert the shield over the nipple and try again. With a little patience a child can generally be taught to take the breast as readily through the shield as through the unprotected nipple.

Still worse local conditions are those of lymphangitis of the breast and abscess of the breast, both of which are usually due to septic infection from a fissure. Maygrier records the case of a child who died from being suckled on a breast affected with lymphangitis. *Post mortem* pus was found abundantly in the digestive organs and the nervous system, the respiratory organs being uninvolved and the umbilicus healthy. Abscess sometimes arises

from the breast being imperfectly emptied during the first three days after confinement by the child suckling every hour and a half or every two hours, as it should do in order to relieve any tension present in the gland.

In the presence of a mammary abscess, or a mastitis that has not reached a suppurating stage, both suckling and the use of the breast-pump must be absolutely forbidden, complete local rest being essential to recovery. A saline cathartic must be administered, *e.g.*, a full dose of Epsom salts, and two-grain doses of quinine three or four times a day. The local treatment consists in the free application of a mixture of extract of belladonna and glycerine in equal parts, and surgical interference if there is evidence of pus.

If the inflammatory process stops short of suppuration and resolution ensues, the milk secretion is sometimes continued and nursing can be resumed.

If the gland is affected by any form of malignant disease or by tuberculous disease breast-feeding must not be permitted.

Tuberculous disease of the breast is uncommon. Sidney Martin found only one case recorded among thirty thousand patients at the Brompton Hospital for Diseases of the Chest. No doubt they would not all be carefully examined. Primary tuberculosis of the breast has been recorded by E. P. Davis (1897) in a girl, aged seventeen, seven and a half months pregnant. Secretion squeezed out of the nipple contained tubercle bacilli. There was no other evidence of tubercle. The child was born healthy. No tubercle bacilli were found in the placenta. The breast was amputated six weeks later and the

mother made a good recovery. Other cases have been reported.

Evidence of old mastitis is not of importance, except as indicating that the affected breast is imperfect and therefore incapable of its full physiological activity. When such a condition is present the infant must be watched with more than ordinary care, in order to ensure that it gets a sufficient supply of food.

The Condition of the Infant.—During the first week of life the temperature may rise if the food is insufficient. Apart from this, the only reliable evidence of an insufficient milk-supply is the lack of gain in weight. The evidence of the mother alone is not enough for a reliable conclusion as to the quantity of milk. Few women, who are anxious to suckle their infants, will confess that the milk secretion is insufficient in amount. Weighing the child before and after suckling will give the weight of milk obtained at each feed. If the quantity is not deficient an analysis will show if the quality is defective. Observation of the infant while suckling will often indicate where the fault lies. When the quantity is deficient and the quality good the infant seizes the nipple as if famished, sucks vigorously until the breast is empty and then drops the nipple with an angry cry. If the milk is poor but abundant the child takes the breast languidly and lies long at it. An analysis will alone settle the point satisfactorily. Deficiency in quantity or quality necessitates partial weaning and supplementary feeding, unless it can be remedied by treatment directed to the condition of the mother.

Irregular and disturbed sleep, fretfulness and

crying, and abnormal stools, are all indications of something wrong with the milk-supply.

Gastro-intestinal disturbance is due to over-rich milk and is the most common indication that the milk is unsuitable. Slight disturbance is evidenced by flatulence and colicky pains, fretfulness and irritability, an apparent craving for the breast as if unsatisfied, and often constipation. In such cases it is almost invariably found that the milk is too rich in proteid. In a child, six weeks old, son of a primipara of the upper middle class, all these symptoms were present. The constipation was especially marked, hard solid motions being passed with considerable straining and tenesmus. Analysis of the milk showed 3·865447 per cent. of proteid, as estimated by Kjeldahl's process for estimation of nitrogen.

A temporary attack may be due to some food or drink or drug taken by the mother. This form of intestinal derangement does not necessitate complete weaning, often not even partial weaning. It is so commonly due to too great frequency of suckling and too short intervals between the nursings that it can generally be remedied by diminishing the number of feeds and consequently lengthening the intervals. For immediate treatment give a small dose of castor oil, half a teaspoonful to one teaspoonful, in order to empty the intestinal tract of the masses of undigested curd.

If the less frequent feeding does not procure relief, an analysis must be made to determine if the proteid is in excess or the fat deficient. Having found out the reason why the milk disagrees, a rational attempt can be made to remedy it, and weaning must not

be thought of until all such attempts have had a fair trial and have failed. No artificial milk-mixture is as good as mother's milk.

If, in spite of this treatment, the intestinal derangement continues and is not cured by the administration of simple drugs, *e.g.*, small doses of alkalies and carminatives given before nursing, and if the child is losing flesh and becoming pale and flabby, it must be partially or entirely weaned. Occasionally simple dilution of the mother's milk, as by giving the child a small quantity of plain boiled water or thin barley water immediately before nursing, will enable the child to deal successfully with an excessive percentage of proteid.

Sometimes an infant will not take the bottle, or artificial food given in any way, as long as it can get the breast. With a little patience and perseverance any infant can usually be taught. If not, complete weaning will be necessary.

Other conditions in the infant, such as delayed dentition, widely open fontanelle, sweating about the head, soft and flabby muscles, and other premonitory symptoms of rickets, indicate that the milk is insufficient in nutritive value or unsuitable in composition. In such cases either additional food or entire weaning may be desirable.

Weaning. — As a general rule, breast-feeding should be continued as the sole source of nutriment for the infant for a period of nine or ten months. At the end of that time weaning should be begun gradually; partial suckling being continued for four or five weeks longer until the child is entirely weaned. Under certain circumstances breast-feeding may be continued until the end of the twelfth month.

The chemical composition of the milk is a matter of considerable importance. If it is plentiful and of good quality the time may be prolonged. The period at which lactation fails varies very largely in different classes and individuals. Among the higher classes the secretion of milk may cease or diminish during the sixth or seventh month of lactation, and in many individuals even at an earlier date. The continuance of the secretory activity depends on the physical health and strength of the mother, on the mode of life and the regularity of nursing.

Physiological Considerations.—The amylolytic ferment in the saliva is secreted in very small quantity during the early months of life, and that of the pancreas does not develop until even later. Ptyalin does not appear in the saliva to any marked extent until the sixth month. The full amylolytic power of the saliva is not reached until the end of the first year. Consequently the conversion of starch into maltose and dextrose takes place only to a very small extent during early infancy. This will be referred to later, in connection with the digestibility of starchy foods and their suitability for young infants.

Starchy foods should not be given to young infants, except in small quantities and very weak solution, until the time of weaning.

Probably the development of four to six incisor teeth corresponds in point of time with a good development of the amylolytic function in the normal infant. Sometimes the lower central incisors are cut abnormally early, a few infants being born with them already cut. As a rule they are cut between the sixth and eighth months, while the

upper central and lateral, and often the lower lateral ones also, appear before the end of the first year. We may take, then, the appearance of six teeth as an indication that the infant may have additional food of a starchy nature. It must be clearly understood that food of this nature is not essential as long as a sufficient supply of good cow's milk is available. There is no doubt that such food can be digested at an earlier period, but it by no means follows that it is necessary or advisable to give it.

Indications for Delaying the Time of Weaning.

1. **Conditions of Ill-health in the Child.**—In debilitated conditions and during, or after, acute illness it is not advisable to wean. The age of the child is not the only factor to be taken into account. Some infants of the lower classes are so neglected and badly brought up that they look, and must be treated as if they are, three or four months younger than their real age.

2. **Hot Weather.**—It is better to wean during cold weather than when it is hot. Our English climate is so variable that we rarely have long periods of heat; hence if the weather is hot we can postpone weaning for a short time. During hot weather there is very much greater liability to fermentative changes in the cow's milk so commonly employed as a substitute for the breast. Under the present unscientific methods of milking, collection of the milk, storage and distribution, the liability to deleterious changes is great in cold weather and enormous when it is hot.

3. **Dentition.**—It is better to choose an inter-dental period, if possible, so as to accustom the infant to its new food at a time when it is not subjected to the nervous disturbance which is occasionally induced by teething.

Methods of Weaning. (1) Sudden. (2) Gradual.—Sudden weaning means that the child is taken completely from the breast and put upon an artificial mixture given in a suitable amount every three hours, from five in the morning to eleven in the evening; that is, it receives seven feeds in the twenty-four hours. For infants under two months old smaller and more frequent feeds are required, in accordance with the capacity of the child's stomach.

Gradual weaning is the method generally adopted, the breast-feedings being replaced one by one by the artificial mixture. It is best to begin in an ordinary case at the end of the ninth month according to the following table.

TABLE XXXVII.

Method of Gradual Weaning.

	1st week.	2nd week.	3rd week.	4th week.	5th week.
5 A.M.	Breast	Breast	Breast	Breast	Breast
8 A.M.	Mixture	Mixture	Mixture	Mixture	Mixture
11 A.M.	Breast	Breast	Breast	Mixture	Mixture
2 P.M.	Breast	Breast	Mixture	Mixture	Mixture
5 P.M.	Breast	Breast	Breast	Breast	Mixture
8 P.M.	Breast	Mixture	Mixture	Mixture	Mixture
11 P.M.	Breast	Breast	Breast	Mixture	Mixture

By proceeding in this gradual way the child's stomach and digestion adapt themselves to their new duties. Time is also allowed for finding out the form

of mixture suitable to the particular infant. Sudden weaning, on the other hand, is much more liable to upset the infant, but it is often carried out quite successfully. It has a greater chance of success if an analysis of the mother's milk has been made at an earlier period, when the child was thriving, for when the proportions of the different constituents are known it is less difficult to devise a suitable artificial food. Even then the results are uncertain, on account of the differences between the caseinogen of human milk and that of other animals, especially the difference in the mode of coagulation by the action of gastric juice.

An empirical mixture may be tried in either mode of weaning, based on the average comparative composition of human and cow's milk. The following is a suitable mixture for a child of six to nine months:

TABLE XXXVIII.

Milk Mixture.

Cream	1 ounce
Milk	2 ounces
Milk or cane sugar . .	1 teaspoonful
Barley water . . .	3 ounces

This may be increased to eight ounces if the child is not satisfied, by slowly increasing the milk to four ounces. The mixture should always be tested and, if it is found to be acid, half an ounce of lime water or bicarbonate of soda solution should be added in place of half an ounce of the barley water. It must of course be given warm, out of a clean bottle with a plain clean rubber teat. If during weaning vomiting and diarrhœa occur, the breast-feeding had better be resumed until the child is recovered. Such attacks

are often induced by the artificial food being too rich in proteid or fat, and can be remedied by further dilution of the milk mixture.

In sudden weaning the child may refuse the substitute food for some hours or even a whole day, but it will give in to the cravings of hunger if the mother perseveres.

If the child is well and gaining weight, weaning is not always necessary as early as has been advised, but such infants must be watched very carefully. I have frequently come across infants between ten and sixteen months of age who are entirely breast-fed, and are fat and well nourished, occasionally extremely fat, and yet show well-marked signs of rickets. It is clear that such infants require supplementary food and have required it for some time. They ought to be weaned as soon as possible.

CHAPTER IX.

COW'S MILK: ITS COMPOSITION AND CHARACTERS.—THE MILK-SUPPLY. MILK FROM ONE COW.—TYROTOXICON.

In general composition cow's milk resembles human milk, containing the same proximate principles of food. In percentage composition it differs very markedly as to some of its constituents. Besides this percentage difference, there are other important considerations to be borne in mind with regard to cow's milk, which indicate that it may be an unsuitable or even dangerous food at times for young infants. Thus bacteriological examination shows that it is crowded with micro-organisms and that it is a very suitable medium for their growth and multiplication. It is by no means uncommon for specific fevers to be spread by the milk-supply.

Chemical examination shows that it is acid when it reaches the consumer, whereas human milk is alkaline. This acidity is due to lactic acid. When secreted it has an amphoteric reaction, turning litmus blue and turmeric brown. The reaction varies with the test used. With phenolphthalein it is acid; with litmoid it is alkaline. With litmus it may be amphoteric, due to two salts of opposite

reaction, namely, acid and alkaline sodium phosphate. Under certain conditions of diet it may be markedly alkaline.

Microscopical examination will often show that it contains many deleterious substances, such as particles of manure, hairs, &c.

From the practically unlimited supply there is a danger of over-feeding.

The total solids vary within considerable limits, dependent upon the breed of the cow, the period of lactation, and the nature of the food. The total solids, less fat, vary within comparatively small limits, from 8·5 to 11·0 per cent., and are only exceptionally below the lower limit. Recent investigations tend to show that the lower limit should be taken as 9·0 per cent.

Each cubic millimetre contains in suspension from two to three millions of fat globules. The fat is a mixture of neutral palmitin, olein and stearin, and glycerides of the fatty acids, palmitic, stearic and oleic. Glycerides of certain volatile fatty acids, chiefly butyric, and others such as caproic and caprylic, are present in small quantities. Over 40 per cent. of the fat consists of olein.

The albuminoids consist of caseinogen, lact-albumin and nuclein or nucleo-albumin. According to Wynter Blyth there is also a small proportion of peptone. Babcock and Russell state that both peptones and albumoses are found. Lacto-globulin may be present.

Hammarsten asserts that the caseinogen, in the absence of lime salts, is curdled by acetic acid, but not by rennet. He regards the curdling as due to the splitting of the caseinogen into two bodies, one

of which is an albuminoid and remains in solution. The precipitate due to acids is very different from the curd due to rennet.

Extractives and other substances have also been found in milk, such as creatin, creatinin, xanthin, hypoxanthin, urea, lecithin, cholesterin, citric acid and mineral salts. Some of these are probably due to the processes used in making the analyses.

Cow's milk has been very frequently analysed, and the results do not show nearly the same discrepancies as the results of the analysis of human milk. In the following table are given the results obtained by various independent observers. My own results were obtained by the methods detailed in the subsequent pages.

TABLE XXXIX.

The Average Composition of Cow's Milk.

Observer.	Water.	Solids.	Proteids.	Fat.	Sugar.	Salts.
A. V. Meigs .	88·549	11·451	2·792	3·310	4·898	0·451
A. V. Meigs .	87·012	12·988	3·252	4·209	5·000	0·527
Parkes (average)	86·8	13·2	4·0	3·7	4·8	0·7
König (average)	87·41	13·04	3·76	3·66	4·92	0·7
Wynter Blyth .	86·88	13·12	4·92	3·50	4·00	0·7
Gorup-Besanez	84·24	15·76	4·32	6·47	4·34	0·63
Fèry (average) .	91·008	12·028	2·812	3·40	5·216	0·60
Langlois * .	87·77	12·23	3·40	3·34	4·92	0·57
Hoppe-Seyler † .	85–86	14–15	3·3–4·5	4·0	4·5–5·0	—
Cheadle † . .	87·1	12·9	4·374	3·499	4·403	0·671
Leeds . .	87·7	12·3	3·75	3·75	4·42	0·64
Author ‡ . .	87·00	13·00	4·06	3·70	4·48	0·76

* The average composition of Paris milk.

† The mean of various collected analyses.

‡ The mean of eight complete analyses. The results obtained in each analysis were reduced to percentages, and the average of these percentages taken for the above table.

It is noticeable that the lowest proportion of proteid is given by Meigs. Just as in the case of human milk, this authority found the proteid percentage less than that commonly accepted. Probably in both instances the amount is under-estimated. He is supported in his results by Fèry. The other observers give averages ranging between 3·75 and 4·374. The average deduced by Hoppe-Seyler of 3·3 to 4·5 is a very accurate one, as including the most reliable results.

The percentage of fat may be taken as ranging between 3·5 and 4·0, but in any particular instance the proportion of fat may be considerably larger.

The amount of sugar ranges between 4·0 and 4·5 per cent. It may reach a higher figure, but there is considerable risk of over-estimating the sugar, so high results must be viewed with suspicion.

The proportion of salts varies only slightly.

The methods of analysis employed by me are tedious and complicated. They can be applied to the analysis of human milk. The results are probably fairly accurate.

Many other methods are employed, and are detailed in the various works on milk analysis. The chief difficulty, as in the analysis of human milk, lies in the estimation of the proteid and sugar separately. The sugar is very constant in amount. Hence, if the total solids and the fat are estimated, the difference represents the proteids, salts and sugar, and the proportion of proteids can be roughly calculated.

Method of Analysis.—Take a pint of milk and put it in a beaker, stir it up and mix thoroughly, then take the specific gravity by an ordinary

urinometer or a lactometer. Test the acidity by placing a few drops on a clean filter paper and allowing the fluid to soak through on to blue litmus paper. Place 100 cubic centimetres aside in a stoppered graduated glass cylinder and allow it to stand for twenty-four hours in an incubator at 18° to 20° C. in winter, or at the ordinary temperature of the room if the weather be hot. Read off the percentage of cream which rises to the surface.

Pour 50 c.c. of the thoroughly mixed up milk into an accurately graduated burette and run out rapidly the following portions :

(1) 10 c.c. into a beaker,
(2) 5 c.c. into a Schmidt's graduated stoppered tube,
(3) 5 c.c. into a small flask holding about 50 to 100 c.c.,
(4) 5 c.c. " " "
(5) 5 c.c. " " "
(6) 5 c.c. " " "
(7) 5 c.c. into a previously weighed platinum capsule,

and proceed as follows :

Estimation of Sugar.—Dilute (1) with about 50 c.c. of distilled water and add dilute acetic acid. Filter off the precipitated caseinogen, mash up and wash the precipitate twice or three times with water and add the washings to the previous filtrate. Make the filtrate up to a known quantity, *e.g.*, 200 c.c. Place in a burette and estimate by means of Fehling's solution. Some writers recommend that the filtrate should be well boiled and again filtered, in order to get rid of the albumin before estimating the lactose. Some recommend that after the albumin has been coagulated by heat the lactose should then be converted into dextrose by boiling for half an hour with a little dilute sulphuric acid.

Others recommend boiling with dilute sulphuric acid before the albumin has been separated. I have found that the method above described gives the most satisfactory results and that, if the filtrate be boiled with dilute sulphuric acid, numerous reducing bodies are formed, unless it has been previously freed from nitrogenous compounds. Fehling's fluid gives better results and is more reliable than Pavy's or Knapp's. It is also easier to work with; the only precaution necessary is to run in the fluid from the burette quickly, while the Fehling's fluid in the capsule is kept boiling. If it is run in slowly reduction takes place with a less amount of fluid, probably due to the formation of reducing bodies by the action of heat on albumin. The average result obtained in my analyses by this method was 4·48 per cent. The variation was small in the eight samples from which this percentage is calculated, ranging only between 3·75 and 5·26. In each analysis three or more estimations were made.

Estimation of the Water and Total Solids. —Weight portion (7) as soon as possible after measuring it out; before evaporation takes place. Multiply the weight obtained by 20; this gives the weight of 100 c.c. of the milk. The average of the eight samples was 101·9 grammes. The variation ranged from 101·22 to 103·4 grammes.

Place the weighed capsule and its contents in an incubator at 40° C. and allow the milk to evaporate to dryness, to a constant weight. The weight, minus the weight of the capsule, multiplied by 20 gives the total weight of solids in 100 c.c. milk. The total weight of solids subtracted from the 100 c.c. of the milk gives the weight of water.

The results were as follows :

Solids—11·72 to 14·66 : average, 13·12 grammes in 100 c.c. of milk.
Water—85·34 to 90·34 : average, 87·54 „ „

Estimation of Salts.—Take the platinum capsule containing the dried solids and heat it until all the contents are incinerated and only a white ash remains. The capsule should not be heated to redness for, if so, small portions of the salts may be volatilised.

The salts varied between 0·68 and 0·79 gms. ; an average of 0·77 gms. per 100 c.c. milk.

TABLE XL.

The Ash of Cow's Milk (WEBER and FLEISCHMANN).

Chlorine	15·60–16·34
Sulphuric acid	0·05–0·10
Phosphoric acid	26·00–29·13
Iron oxide	0·33–0·62
Lime	17·30–27·00
Magnesia	1·90–4·07
Potassium	17·34–24·50
Sodium	7·00–11·00

Estimation of Fat.—Portion (2) ; 5 c.c. of milk in a stoppered tube graduated to 50 c.c. is shaken up with 10 c.c. of strong hydrochloric acid and placed in a hot water bath until it turns dark brown in colour, from the conversion of lactose into maltose, and becomes clear except for a little floating coagulum of lact-albumin. The caseinogen is converted into acid albumin. It is then cooled under the tap and when cold 35 c.c. of ether is added. Shake up well for a few minutes and allow to stand. In a quarter of an hour the fluid will be seen to consist of three layers, an upper clear layer of ether containing fat,

a lower clear layer of acid albumin, water, &c., and a narrow, intermediate, flocculent, white layer, about half an inch thick, of coagulated albumin. Read off the depth of the ether layer from the 50 c.c. mark to the middle of the layer of coagulated albumin. Then measure off rapidly two 10 c.c. portions of the ether layer into previously weighed platinum capsules; place them in the hot incubator and, when the contents have evaporated down to dryness and a constant weight, weigh them. Take the mean of the two estimations, and from that estimate the weight of fat in the whole ether layer, that is in the five cubic centimetres of the milk under examination. Multiply by 20 to obtain the weight of the fat in 100 c.c. of milk (Schmidt's method). I found in these analyses that the weight of fat varied between 3·495 and 4·2 grammes. The percentage of cream on standing for twenty-four hours varied between 6 and 9.

Another useful apparatus for fat estimation is Gerber's acido-butyrometer. It consists of a glass tube, with a graduated scale, into which the milk and reagents are placed. It is then corked, the contents thoroughly mixed by shaking, and subjected to centrifugal force in a gyrostat, set in motion by a piece of cat-gut wound round the axle and pulled quickly as in spinning a top. Let the gyrostat spin for three minutes, take out the graduated tubes and stand them in warm water for a few minutes and then read off the percentage of fat from the scale. The reagents used are sulphuric acid of a definite strength, sp. gr. 1820 to 1825 at 60° F., and the purest amyl alcohol obtainable. Mix 10 c.c. of the acid, 1 c.c. amyl alcohol and 11

c.c. milk in each tube. Smaller quantities of milk can be used if diluted to 11 c.c.

Marchand's lacto-butyrometer is used in another method. It is a graduated glass tube. Pour in 5 c.c. milk and a drop of caustic soda solution; add 5 c.c. ether and shake the tube until the fat is extracted by the ether. On adding absolute alcohol and warming, the fat rises and can be calculated from the depth of the layer in the tube according to a special formula. I did not find this method as satisfactory or as easily carried out as that of Schmidt.

Babcock's apparatus for estimating fat is rapid and reliable. A reduced size can be obtained, suitable for small quantities of milk. It consists of a special bottle, two pipettes and a centrifugal machine. The reagents used are chemically pure sulphuric acid (Merck's, sp. gr. 1083), fusel oil and concentrated hydrochloric acid. After centrifugalising for two minutes the column of fat is read off from a scale on the neck of the bottle. The chemical process is that of Leffmann and Beam. The process is very accurate and does not take more than five minutes. Several specimens can be examined at the same time.

Feser's lactoscope is an apparatus in which an optical test is used. It requires experience, is modified by the personal equation, and is unsatisfactory.

Estimation of Total Nitrogen.—This was carried out from portion (3) by Kjeldahl's process, as described in Halliburton's "Text-Book of Chemical Physiology and Pathology." In estimating the proteids the same process was adopted; the proteids being calculated from the amount of nitrogen ob-

tained by their decomposition. The process is a tedious one.

The total nitrogen varied between 0·476 and 0·84 grammes per cent.

Estimation of Total Proteid.—The proteids were precipitated by the addition of a saturated solution of tannic acid to portion (4) and separated by filtration through glass wool.

Variation . .	3·29966 to 5·17244 grammes per cent.
Average . .	4·06 grammes per cent.

Estimation of Caseinogen.—The milk in portion (5) was diluted and a little acetic acid added; the precipitate being separated by filtration through glass wool.

Variation . .	2·10468 to 3·74556 grammes per cent.
Average . .	2·61 grammes per cent.

In some of the analyses the caseinogen was also estimated from the precipitate obtained by saturation of portion (6) with magnesium sulphate. The results obtained by this method were equally satisfactory, but the process was rather more troublesome. In one analysis the results obtained by the two methods were identical to the fifth place of decimals.

Estimation of Albumin.—The lact-albumin was estimated from the precipitate obtained by adding tannic acid to the filtrate, after the separation of caseinogen, by the addition of acetic acid or saturation with magnesium sulphate.

Variation . .	1·07016 to 1·997632 grammes per cent.
Average . .	1·41 grammes per cent.

The Proportion of Caseinogen to Albumin.—The average proportionate relationship of the proteid coagulable by gastric juice and rennet ferment to the uncoagulable proteid in these analyses is 2·61 of the former to 1·41 of the latter. Most commonly there was found practically twice as much caseinogen as albumin. The percentage of albumin obtained is much higher than that usually given.

The Specific Gravity varied between 1029 and 1035; that usually given as the ordinary variation is 1028 to 1034. It may reach as high as 1040 (Klimmer). It is always higher than that of water, on account of the proteids, sugar and salts. Fat is of lower specific gravity than water, but in milk there is not sufficient to counterbalance the effect of the other solids.

Increase in the proportion of fat (cream) lowers the specific gravity, and so too does the addition of water. Diminution in the proportion of cream, or increase in the proportion of other solids, raises the specific gravity.

Hence, if cream be removed from milk, the specific gravity is raised; the addition of water will bring it back to what it was before. Consequently from a rich milk, of specific gravity of 1030 for instance, by removal of cream and addition of water, a poor milk of the same specific gravity can be prepared. It is clear, therefore, that the specific gravity alone is no test of the nutritive value of the milk.

A Method for the Rapid Examination of Milk.—Practically the only fraud in milk dealing that bears on its nutritive value, consists in the removal of cream. The proteids, sugar, and salts are never removed. In order readily to detect such

a fraud the following method may be employed. Place 100 c.c. in a graduated vessel (or fill any glass tube graduated in 100 parts), take the specific gravity, and allow it to stand for twenty-four hours. Read off the proportion of cream which rises to the surface. If the specific gravity is within the limits above quoted, and the percentage of cream on standing not less than nine, it may be considered good average milk. The higher the percentage of cream and the lower the specific gravity, the less likely is it to have been tampered with.

Variations in the Specific Gravity and Percentage of Fat.—Provided that the milk has not been tampered with, the specific gravity will be found to vary chiefly with the proportion of fat. This differs largely in different cows, in the same cow at different times, in the same cow at the same period of the day, and during the same milking according as the fore milk, middle milk or strippings is taken for analysis (*vide* Table XXVII. p. 89).

Alderney cows, as a rule, yield a milk richer in cream than that of other varieties. Stall-fed cows in London give occasionally milk richer in solids, especially fat. This depends on the diet of the animal. The fore milk, that first drawn from the udder, is very deficient in fat and practically resembles skim milk. The strippings, or that last drawn, are so rich in cream that they are sometimes milked into a separate receptacle and sold as cream. It is therefore of great importance, when analysing the milk of any particular cow, to obtain the whole of the mammary secretion and not a portion guessed at as the middle milk.

Cream.—The difference between milk and cream

is essentially a difference in the percentage of fat. This can be satisfactorily estimated by the Babcock process. We speak of two kinds of cream, according to how it is prepared. "Gravity cream" is the cream obtained by skimming after the milk has stood a variable period, usually twenty-four hours. "Centrifugal cream" is that obtained by the use of a separator, a centrifugal machine. The process is a rapid one and the cream is fresher. Possibly to a slight extent the centrifugal force breaks up the emulsion. The richest centrifugal cream may contain as much as 40 per cent. fat. In all cream there is a reduction in the proportions of proteid and sugar, with the increase in the amount of fat. Gravity cream is very variable in quality. It usually contains 12-16 per cent. fat. It does not keep well and consequently is often preserved by means of ice and the addition of preservatives. From the fact that it thickens with age it may be kept in order to make it appear richer. Sometimes it is merely rich milk.

If the cream is obtained by skimming it is important that it should be obtained from the milk of a mixed herd and not from a fancy cow; that the milk should be allowed to stand at the same temperature and for the same length of time before skimming; and that the same person should skim it. Without such precautions the percentage of fat in the cream will vary very largely.

Centrifugal cream in town is separated from the mixed milk of many animals, and consequently varies very slightly, usually containing about 20 per cent. of fat. Possibly the mechanical process alters the surface tension of the fat globules in relation to the

pressure and causes them to become more coherent. The gravity process is a useful one for obtaining cream with various percentages of fat. To obtain a 12 per cent. fat cream stand a quart of milk in a glass jar in ice water for six hours and take the top six ounces. To obtain an 8 per cent. fat cream stand the milk for only four to five hours and take the top ten ounces. Of course these results are not absolutely reliable, but with a good mixed milk they are sufficiently so for practical purposes. For the sake of the consumer all cream should be sold according to the percentage of fat it contains. It should be pasteurised at the dairy, cooled down, and kept in ice water.

The Milk-Supply.—By the time the milk reaches the consumer in a large town, especially in London, it has been exposed to innumerable risks of contamination and can no longer be considered either clean or fresh. Certain precautions ought always to be adopted and, though some of these are enforced by law, a large number are neglected or unnoticed. It is not even contrary to law to distribute in other districts milk condemned in a particular district. The management of our milk-supply is a disgrace to a nation possessed of a scientific knowledge of the diseases dependent upon it. In the first place, only the milk of healthy cows should be taken and that of an indisposed animal must on no account be mixed with the remainder. An animal showing the least sign of general malaise, or of any eruptive or other affection of the udders, should be kept separate from the rest of the herd. The cow is a peculiar animal in many ways. Her nervous functions are exaggerated, for she is always either in milk or

pregnant. Frequently in-breeding is carried on to a large extent. She is highly nervous and excitable, with a marked tendency to tuberculosis. This disease is very prevalent among old milk cows kept in badly ventilated cowhouses. The use of tuberculin as a test for tuberculosis in dairy cows ought to be insisted on, and all cows destroyed which give the characteristic reaction. The normal temperature of the cow is very variable; it is usually stated to be between 98° F. and 101° F. Brush found it higher and still very variable, even when the animal was in apparent health, as judged by the due performance of her functions with profit to the owner: the average of several hundred observations was 102·5° F.; range 101·5° F. to 103° F.

The failure of cow's milk to give satisfaction, when it is employed as a substitute-food in the artificial feeding of infants, depends on several conditions:

1. A faulty condition of the cow.
2. Improper feeding or care of the animal.
3. Improper or careless methods of milking.
4. Improper handling of the milk from the time it is drawn from the udder to the time when it reaches the consumer.

Faulty Conditions of the Cow.—The best milk cows for infant feeding are Shorthorns, Ayrshires, Kerrys, Devons and Red Polled. They are hardy and reliable. Jersey, Alderney and Guernsey cows yield a milk containing a higher percentage of fat, but they are more liable to disease. The milk may deviate from the normal standard in various conditions of local or general disease; for instance, tuberculosis of the lungs or udder, foot and mouth disease, pleuro-

pneumonia, and many local affections of the udder. The milk of such animals should on no account be used. The cow may be old and the period of lactation unduly prolonged; its milk will be thin and watery and deficient in fat. It may have recently calved and its milk contain many colostrum corpuscles; such milk is certain to disagree. When the cow is "bulling" its milk is liable to upset the child.

Effect of Diet.—Plenty of food and little exercise increase the yield of milk. A sufficient supply of water is necessary. Nitrogenous food is beneficial in increasing the yield and the percentage of fat. In order to provide a milk that is suitable for the infant on account of its richness in fat, the cow should be fed on highly nitrogenous, rather than on starchy and fatty foods.

It has been found by experiment that cows fed freely upon sugar beet produce a faintly alkaline milk; that cows fed partially on beets yield a neutral or faintly alkaline milk, and that if one part of this milk is added to two parts of the acid milk from cows which have had no beets in their food, the mixture becomes faintly alkaline.

Cows set aside for providing milk for infants should not be fed on fermented foods, such as the refuse of breweries. They should not be allowed to drink stagnant water, and their pastures should be free from noxious weeds and decaying leaves. Some plants taken in the food will alter the colour of the milk; some may contain poisonous principles.

The water should be obtained from ponds supplied by springs, fenced round and protected from surface drainage. It is even better that the water should

be supplied in troughs filled from the pond or spring. Frequently it is found that the milk from cows fed on turnips and linseed or cotton cake disagrees with infants; turnips more especially appear to render the milk unsuitable. Only recently I came across a case where the milk of a cow fed on turnips caused violent gastro-enteric disturbance in a child six months old. The cow's diet was changed to one of hay and oats. and the milk then agreed perfectly. The milk of cows pasture-fed is much more likely to agree than that of stall-fed animals. Good food is essential to the production of good milk. Sudden changes in the diet are bad and likely to cause temporary disturbance of the milk supply.

Cow-houses should be built of impervious material; the floors paved or cemented, raised and sloping down to a broad gully to receive the excreta. This gully should have a gentle fall and lead into a tank outside the cow-house, receiving the liquid excreta and frequently emptied. The fittings and troughs should be made of impervious material. The roof, walls, and wood-work must be well lime-washed, and washed and lime-washed whenever dirty. No deposit of manure should be allowed near the sheds, and all yards and barns must be kept scrupulously clean and well drained. The bedding should consist of clean straw, peat-moss, sand or saw-dust. Soiled bedding must be removed twice a day. The floor should be swept an hour before milking. Plenty of light and ventilation are essential but the sheds should not be draughty. A temperature of about 50° F. is the most suitable. Only a limited number of cows should be kept in the same shed. The stalls should be roomy. The addi-

tion of an exercise yard for use in winter is very advantageous.

If the cows have to come from pasture before being milked they must on no account be hurried or frightened; let them be driven slowly and without the aid of a dog.

Milking and Handling of the Milk.—The cow must be kept clean like a well-groomed horse. Before milking, the udder and teats should be gently washed with warm water and dried with a soft towel. The hands of the milker should be washed before and after milking each cow. Both teats and hands must be kept dry while milking. The milker must wear a clean overall. The milk pails should be thoroughly scalded out with boiling water and kept in the open air or in a clean, airy barn until required for use. Milk on cooling absorbs odours from dirty cow-houses and barns. Such odours can be got rid of:

(*a*) By pouring the milk in a thin stream from can to can in the open-air.

(*b*) By pumping in pure air by means of a suitable machine.

(*c*) By the addition of nitrate of potash. This is a method which certainly ought not to be permitted. Glycerides and sulphates are found in decomposing milk and these bodies may combine with the nitrates, produced by the activity of microbes, and form bodies allied to nitro-glycerine. Tyrotoxicon is a body sometimes found in unsound milk and occasionally it detonates under examination in the laboratory, suggesting an approximation to nitro-glycerine. Moreover, the toxic effects of nitro-glycerine are similar to those of tyrotoxicon.

After the milk has been drawn and aërated it should be at once thoroughly cooled. Where possible, the best means of cooling is to place the can in a running stream; if a stream is not available the can should be surrounded with ice-water. During cooling the can should be uncovered and the milk frequently and gently stirred. The temperature should be reduced to 60° F. in an hour, and the can kept in cold water until it is sent off for delivery. It is even better to cool the milk down to 40° F. and supply it at that temperature. At no time should the milk be frozen. When sent by rail the milk cans should be placed in a van built on the principle of a refrigerator. It is a pity that our big railway companies do not build a sufficient supply of such vans for the purpose.

As at present delivered to the customer, it is usually put into small metal cans of a suitable size, generally being ladled out of a bigger can, occasionally let out through a tap placed at the bottom. Both methods are unsatisfactory. In the former the milk becomes terribly contaminated by dust and other matters getting in during the frequent removal of the cover, especially on a dry and windy day. In the latter, the earlier customers suffer to the advantage of the later ones, on account of the cream rising to the surface. The milk ought to be cooled, bottled, and sealed at the dairy in the country, kept at 50° F., and reach the consumer in six hours. Milk can be now obtained delivered in bottles, in even less time than this.

As at present received the only precautions the consumer can take are to see that no milk is taken in at a higher temperature than 65° F. and, if for

an infant, that it is not more than twelve hours old. Two sets of milk cans should be used, and each thoroughly scalded out as soon as emptied. In summer the milk should be at once slightly boiled, then rapidly cooled and placed in the refrigerator. Light as well as heat hastens decomposition. Our country is a very long way behind Denmark in the management of its milk-supply. Copenhagen is very well and scientifically supplied by a company. The milk is brought to the company by various farmers, and great care taken that none but sound milk is admitted. The regulations provide payment for the milk of any indisposed cow at the ordinary rate, and wages for any one engaged in milking, &c., who is affected by any infectious disease. Consequently it is not to the advantage of the dairyman or his employés to evade the regulations. The milk is cooled down to 40° F. and all the processes are carried out at this temperature, at which also it is supplied to the consumer in carefully sterilised bottles corked with clean new corks. The company guarantees the veterinary control of all the cows from which the milk is obtained and the exclusion of the milk from suspected animals; the cooling of the milk by ice to 40° F., or lower, both at the farms and the depôt; the filtration of the whole of the milk by upward filtration through fine gravel; and absolute cleanliness of all bottles and cans used, which are supplied under the security of the company's seal. The cows are examined once a fortnight by a veterinary surgeon. An inspector reports monthly on the fodder, the state of the sheds, and the care exercised in the milking process. During summer the food consists of fresh pasture grass and

clover; in winter of hay, oats, bran, and carrots. Extract from the regulations:—"The food of the cows must be of such a nature and quality that no bad taste or taint may be imparted to the milk by it. Brewers' grains and all similar refuse from distilleries are strictly forbidden, as also is every kind of fodder which is not fresh and in good condition. Turnips are strictly forbidden; no kind of turnip leaves may be used. Carrots and mangolds are allowed up to half a bushel a cow, but only when at least seven pounds of corn, bran, and cake are given with them. Rape-seed cake is the only oil-cake which may be used. Cows kept for infants' milk must not receive any oil-cake. Stall feeding in summer will not be permitted under any circumstances. The cows must be fed in the open air on clover and grass; vetches are forbidden. In autumn the cows must be clipped on the udder, tail, and hind-quarters, before being taken in. The milk of cows newly calved must be withheld for twelve days after calving and must not be less in quantity than three quarts per day. Immediately after milking, during all seasons of the year, the milk must be cooled down with ice-water to 40° F."

Until some such system is introduced into our own country for the supply of milk to the inhabitants of towns, the mortality of infants and the prevalence of typhoid fever and other diseases spread by milk will remain practically unchecked and uncontrolled.

Some of our large dairy companies have progressed partially in this direction. A sanitary condition of the farm and farm buildings, the possession of a good water-supply, suitable boiler and a

refrigerator is insisted on. The farmer is bound down not to tamper with the milk in any way, to strain and refrigerate it, to scald and clean thoroughly all vessels, and not to send the milk of any cow which is out of health or in physic. He is also indemnified against any loss resulting from the outbreak of any infectious or contagious disease among those engaged in the dairy work, provided that notice is given to the company, if for that reason the milk is deemed unsuitable for delivery.

At present there is no company in London which supplies milk on a large scale in bottles or tins, in the way that the Copenhagen company does, nor any company which sterilises the whole of its milk-supply and sends it out in this condition.

The importance of cooling down the milk to a low temperature and keeping it at that temperature is very great. The lower the temperature the less rapidly do micro-organisms develop in the milk.

The shorter the distance the milk has to travel the better for the consumer. In comparing the value of milk from different distances, attention must be paid to the method and rapidity of transit, and the nature of the road it has to come across.

Preservatives in Milk.—Cow's milk, even in a large town, ought never to be more than twelve hours old. Sometimes it is a good deal more and contains certain chemicals to preserve it, chief among these being borax, salicylic acid, boric acid, and formalin. Out of thirty samples of milk bought in the districts of Westminster, Marylebone, Lambeth, and Battersea, during June 1895, and analysed by Charles E. Cassal on behalf of the British Medical Association Special Commission (*British Medical*

Journal, July 20, 1895), no less than ten contained boric acid and three were artificially coloured. Whether this drug does harm or not in the body the use of it ought to be prevented, as it only enables milk to be sold to the public long after it ought to be used. It requires nearly four grains of boric acid per pint for the preservation of milk. Six grains of this drug is a maximum dose for a child three years of age. Cases of boric acid poisoning from the use of such milk have been recorded. To test for boric acid in milk put 20 c.c. in a beaker, add a drop or two of phenolphthalein solution, and then drop in a solution of caustic soda, about normal strength, until a faint pink colour appears. Pour the mixture into two test-tubes and to one add an equal bulk of distilled water, to the other an equal bulk of a neutral 50 per cent. solution of glycerol in water. If boric acid be present the former tube will become distinctly pinker, and the latter will turn pale or white. Boric acid is very inefficient as an antiseptic. It does not preserve milk as well as borax. The latter in 0·1 per cent. strength inhibits rennet activity. Formalin (40 per cent. formaldehyde) is another preservative largely employed. It is added in the proportion of one drop to the ounce. It delays the action of rennet, gastric digestion, and the pancreatic digestion of fibrin and starch.

In country districts people sometimes drink milk warm from the cow, and occasionally it is recommended for infants. This is a mistake, for it has been found by actual experiment that cow's milk, taken after this manner, forms a firm curd in the stomach and is very indigestible. The curd is not, however, as hard and resistant as that from milk

which is too old. The fresher the milk the better it is for the infant, but no matter how fresh and pure the milk is, it will require modification in order to render it suitable to the digestive capacity of the child.

Milk from one Cow.—How often we hear this recommended as a panacea for an infant with whom the ordinary milk supply does not agree. It is a popular fallacy and in the minds of the profession an incompletely exploded one. Milk from one cow involves a maximum degree of variability, whereas by taking the mixed milk of a herd, the larger the better, a much more uniform standard is obtained. Any individual variation is minimised or lost in the mixture.

It has been shown that the milk of a cow is liable to great variation according to the nature of its food, the period of lactation, and the condition of its health. If lactation is much prolonged the milk becomes very poor and watery.

In the country, where the parents of the child own the cows, it may be sometimes advisable to put one aside for the supply of the infant. In the case of a delicate child, not very tolerant of cow's milk, by reducing the diet of the cow, as shown previously, the milk can be rendered poorer in solids and more digestible.

In a town this is rarely advisable or necessary. Even if one could trust to the honesty of the dairyman, it is unlikely that the milk of one cow, town fed as it is, will be more suited to the requirements of the infant than the mixed milk supplied by some of our large milk companies.

The milk of these companies is more reliable and

less liable to vary than that supplied by some of the small dealers, both on account of the quantity received and the less temptation to dilution and the abstraction of cream. It should always be recommended as the source of supply for an infant, when cow's milk is ordered.

Tyrotoxicon—(cheese poison)—is a substance discovered by Vaughan in stale milk, which produces symptoms resembling those of *cholera infantum.* It has been found in cheese and decomposing milk, in the crevices of badly cleaned cans. Possibly it is present at times in the milk of cows which are diseased.

In order to prepare it milk is allowed to stand until curdled, the curd separated by filtration, and the acid filtrate rendered feebly alkaline by caustic potash. The filtrate is shaken up with ether, the ether separated and allowed to evaporate. The residue is redissolved in water and the poison again separated out by ether. It separates, when the ether evaporates, in a crystalline form with a penetrating cheesy odour.

Tests.—Place two or three drops of pure sulphuric and carbolic acids on a white porcelain plate. The mixture is almost colourless, but on the addition of a few drops of a watery solution of the crystals a colour varying from yellow to orange-red develops.

A small dose of a watery solution placed on the tongue of a dog or cat causes severe gastro-enteric disturbance. In a few moments the animal froths at the mouth, vomits, has spasm of the abdominal muscles, and later free watery purgation.

It reduces iodic acid; turns prussian blue with ferrocyanide of potassium and ferric chloride; is not

precipitated from its solution by ordinary alkaloidal reagents. The crystals decompose if kept at the temperature of the room.

It is extremely probable that some of the epidemics of severe infantile diarrhœa are caused by this poison. These cases occur at a time of year when milk is especially liable to decompose; among the class of people whose surroundings are most favourable to decomposition and in places, such as large towns, where really fresh milk is not supplied. Newton and Wallace, of the New Jersey State Board of Health, reported a number of cases of poisoning by milk in different hotels in the same place. On inquiry it was found that all the milk came from one milkman whose cows were milked at midnight and noon. The weather was very hot and the noon milk was placed in cans without being cooled and carted eight miles during the hottest part of the day. It was this milk which caused the poisoning; the midnight milk delivered in the morning was non-injurious. Possibly the poison in this case was tyrotoxicon and it, or the organism giving rise to it, was generated by the careless manner of collection and transportation.

Inspected and Certified Milk.—In various parts of America milk is supplied under conditions regulated by a committee of medical men. The objects aimed at are the provision of milk of good standard quality, clean, and as free from bacterial contamination as possible. Dairies are inspected, the cows are examined by a veterinary surgeon, and the milk is examined bacteriologically. Regulations are drawn up, on the lines above described, for the proper care and feeding of the cows, the structure

and management of cowhouses and buildings, the water supply, the milkers and milking, the cleanliness of all utensils, and the management of the milk. The difference between the inspected and the certified milk consists in the greater freedom of the latter from micro-organisms, the sterilisation of all dairy utensils, and greater cleanliness generally. In this country some of our large dairy companies claim that they adopt such precautions as these. It would be more satisfactory if their sources of milk-supply were inspected and certified by an independent body.

CHAPTER X.

THE COMPARISON OF COW'S MILK WITH HUMAN MILK. THE PREPARATION FROM COW'S MILK OF A FLUID RESEMBLING HUMAN MILK.

Cow's milk is more opaque in colour, even though it may contain less fat. It is deep white after the fat is removed, while human milk is almost transparent. The colour is partly due to the combination of calcium phosphate and casein.

A drop of cow's milk placed on the finger nail remains convex, with a completely opaque white margin; it does not expand.

The reaction of human milk is alkaline; that of cow's milk, as it reaches the consumer, is acid. Sometimes cow's milk is alkaline when the cow is fed on certain foods. At times the milk of unhealthy women is acid.

The proteids in cow's milk are considerably in excess of those in human milk, the relative proportion in the two fluids being about two to one. Not only is there a total excess, but there is also a difference in the proportions which the two proteids bear to each other in the two fluids. Unfortunately these latter proportions have not been absolutely ascertained. The results of analysis are very different

as obtained by different observers. According to König the proportion of caseinogen to albumin is as 4 : 1 in cow's milk, and as 1 : 2 in human milk; and he calculates that there is five times as much caseinogen in the former as in the latter. Other observers give different results. In the eight complete analyses of cow's milk made by the author the proportion of caseinogen to albumin was about two to one. The relative proportions given by various analysts are recorded in the next table:—

TABLE XLI.

The Relative Proportions of the two Proteids.

Cow's milk.			Human milk.		
Observer.	Caseinogen.	Albumin.	Caseinogen.	Albumin.	Observer.
König . .	2·88	0·53	0·59	1·23	König
,, . .	3·01	0·75	0·63	1·31	,,
Lehmann .	3·00	0·30	1·20	0·50	Lehmann
Wynter Blyth	3·88	0·77	2·40	0·57	Wynter Blyth
Author . .	2·61	1·41	0·63	1·50	Hirt
Gorup-Besanez	3·57	0·75	1·28	0·34	Tolmatscheff
Hoppe-Seyler	3·0–4·0	0·3–0·5	1·8–4·8	0·7–1·7	Makris

All observers are agreed that the proportion of proteid coagulable by acid (caseinogen) is much greater in cow's milk than in human milk. In some respects the caseinogen differs in the two fluids. From human milk it is precipitated with greater difficulty by acetic acid and more readily by magnesium sulphate, and the curd formed by the addition of acid or rennet ferment is finer, more

flocculent and more readily digestible. By diluting cow's milk sufficiently, with from four to five times its bulk of water, the curd obtained on the addition of dilute acetic acid closely resembles that of human milk. The proteid of cow's milk precipitated by gastric juice is much less easily dissolved than that of human milk.

The fat differs only in the size of the globules, which range from 0·001 to 0·2 mm. in diameter in cow's milk, and from 0·00015 to 0·005 mm. in human milk. The globules have no casein envelope, but on the surface of each a number of albuminous particles are condensed by molecular attraction. In other respects cow's milk differs from human milk in containing less sugar and more salts. There is evidence that the sugar is not chemically, physically, and physiologically the same in the two secretions. Tables comparing the two fluids are well worthy of examination.

TABLE XLII.

Comparison between Human and Cow's Milk.

Human milk received direct from the breast.		Cow's milk 12 hours old.
Water	87–88	87–88
Solids	12–13	12–13
Proteids	1–2	3·5–4·0
Fat	3–4	3·5–4·0
Sugar	6–7	4·4
Salts	0–2	0·7
Reaction	Alkaline	Acid
Micro-organisms	Absent	Numerous
Coagulable proteid	Little	Much
Coagulation by acid	Slight	Marked
Coagulation by rennet	None	Firm

TABLE XLIII.

Comparison between Human Milk and Cow's Milk (König).

	Human milk.	Cow's milk.
Water . . .	87·41	87·14
Solids . . .	12·59	12·86
Proteids . .	2·29	3·55
Fat . . .	3·78	3·69
Sugar . . .	6·21	4·88
Salts . . .	0·31	0·71

König gives a higher percentage of proteid as present in human milk than most other observers and a rather lower percentage in cow's milk. Carter and Richmond, Leeds, and Pfeiffer, have all given results so closely alike, and so near 2 per cent., that we may accept this figure as the standard for proteid.

In order to prepare from cow's milk a mixture, as nearly as possible identical in composition with average human milk, we must start with a standard analysis of each, as close to the average as possible. Both fluids have been shown to be essentially variable in composition under varying conditions of diet, health, age, &c. Cow's milk is liable to still greater variation on account of having to pass through the hands of dealers who are not invariably honest.

It is clear that the knowledge of an average standard of each fluid will enable us to prepare an artificial mixture resembling human milk, and most likely to suit the digestive capacity of the infant for whom it is chosen. For this purpose I take the average of my own analyses of specimens of London milk, as it reaches the consumer, as the standard for

cow's milk and, as a standard for human milk, an average deduced from the analyses of Meigs, Leeds, Pfeiffer, Adriance, and Carter and Richmond.

TABLE XLIV.

Standard Comparative Table of Human and Cow's Milk.

	Cow's milk.	Human milk.
Water . . .	87	87·62
Solids . . .	13	12·38
Proteids . .	4·06	1·69
Fat . . .	3·70	3·67
Sugar . . .	4·48	6·79
Salts . . .	0·76	0·23
Reaction . .	Acid	Alkaline

For working purposes this may be simplified as follows:—

TABLE XLV.

Working Table.

	Cow's milk.	Human milk.
Proteids	4·0	2·0
Fat	4·0	4·0
Sugar	4·4	6·6
Salts	0·6	0·2

It is evident that in order to reduce the percentage of proteid in cow's milk to that in human milk a considerable quantity of water must be added, and that the addition of water will reduce the proportions of fat and sugar below those required by the infant. The effect of diluting milk with water in the proportions 1 : 1, 1 : 2, and 1 : 3 is best shown by comparative tables as follows:—

TABLE XLVI.

Composition of Diluted Cow's Milk.

	Milk, 1 part; water, 1 part.	Milk, 1 part; water, 2 parts.	Milk, 1 part; water, 3 parts.
Water . . .	93·5	95·66	96·75
Solids . . .	6·5	4·33	3·25
Proteids . .	2·03	1·36	1·015
Fat . . .	1·85	1·23	0·925
Sugar . . .	2·24	1·49	1·120
Salts . . .	0·38	0·25	0·190

Dilution with even three times the bulk of water only reduces the percentage to what Meigs considers the average percentage present in human milk. Clinically it is sometimes found that an infant can only digest a milk containing about one per cent. of proteid. This may depend upon the excess of coagulable over uncoagulable proteid in cow's milk. The average babe can, as a general rule, digest milk containing two per cent., at any rate after the fourth month of life. In every case of dilution fat and sugar must be added, to raise the proportions of these two substances to what is present in human milk.

Gärtner has recently devised a simple method for preparing from cow's milk a suitable substitute for human milk. Equal quantities of milk and sterilised water are poured into a centrifugal separator which is arranged to revolve so that the two outgoing streams are equal. The milk is thereby separated into two portions with the following composition :

TABLE XLVII.

Percentage of Proteids and Fat in Gärtner's Milk.

	Proteid.	Fat.
Before separation—		
Original milk	3·6	3·5
" " (diluted)	1·8	1·75
After separation—		
"Fettmilch," or cream portion . .	1·8	3·3
"Magermilch," or skim milk portion .	1·8	0·2

In August 1895, before I was acquainted with Gärtner's method, I suggested at the meeting of the British Medical Association to Mr. Richmond, the analyst to the Aylesbury Dairy Company, the preparation of a special milk for infants according to a very similar process. Taking an equal quantity of mixed cow's milk and of a nine per cent. solution of milk sugar, the whole is passed through a separator so arranged that the two outgoing streams are equal. It is thus divided into two equal parts, one of which contains almost all the cream, and may be termed *cream milk*, while the other contains practically no cream, and may be called *skim milk*. The composition of the two fluids will be as follows:

TABLE XLVIII.

Percentage of solids.	Original cow's milk.	Separated milk.	
		Cream milk.	Skim milk.
Proteids	4·0	2·0	2·0
Fat	3·7	3·5	0·2
Sugar	4·4	6·7	6·7
Salts	0·7	0·35	0·35

The company kindly prepared milk according to this method, and supplied it for trial under my supervision at the Belgrave Hospital for Children. The composition of the milk supplied and its comparison with human milk are shown in the adjoining table:

TABLE XLIX.

Comparison of Cream Milk with Human Milk.

Percentage of solids.	Cream milk.	Human milk. (Table XLV.)
Total solids . . .	13·11	12·8
Proteids . . .	1·82	2·0
Fat	4·02	4·0
Sugar	6·88	6·6
Salts	0·39	0·2

The table shows how closely the cream milk approximates to average human milk in composition. It was well taken and digested by infants, but it was found that the percentage of fat was too high for some of them. Since then the amount of fat has been reduced to 3·7 per cent. with excellent results. It is rendered faintly alkaline, Pasteurised and supplied in vacuum-stoppered bottles. Gärtner's method of preparation is simpler and cheaper. After the separation, the addition of four per cent. of milk sugar is necessary. Probably cane sugar is not quite as satisfactory as milk sugar, as it is so sweet. The advantages of this mode of preparation may be summed up shortly as follows:

1. By the process of separation a large number of deleterious substances which accidentally contaminate milk, such as particles of manure, hairs,

epidermal scales from the hands of the milker or the udder, dust, &c., are removed. Needless to say such constituents are very liable to be injurious to the infant.

2. By the process of pasteurisation the countless organisms, present in the milk when it reaches the dairy, are destroyed. It has been shown that a temperature of 160° F. destroys the bacilli of tubercle, typhoid fever, diphtheria and many other diseases. The liability to the transmission of disease to the infant through the medium of the milk-supply is consequently abolished.

3. A substitute for human milk is supplied ready for use, and the trouble involved in the methods at present adopted is abolished. That this trouble is no slight one is well illustrated by reference to the artificial substitute which Rotch recommends:

TABLE L.

Rotch's mixture.

	Ounces.
Cream (centrifugal cream, 20 per cent. fat, diluted $\frac{1}{4}$ or $\frac{1}{3}$) .	2
Milk	1
Lime water (diluted $\frac{3}{4}$)	2
Milk suger solution (lactose $3\frac{3}{8}$ dr., water 3 oz.) . . .	3
	8

This is even more complicated than the mixture which I commonly advise:

TABLE LI.

A Mixture recommended for Artificial Feeding.

Cream (20 per cent. fat)	10 parts—*e.g.*,	1 ounce
Milk	30 ,,	3 ,,
Water	30 ,,	3 ,,
Lime water	10 ,,	1 ,,
Milk sugar	4 ,,	3 dr.

Both these mixtures involve considerable care in the preparation, the buying of four different articles, and a cream of fairly accurate composition, necessarily a centrifugal cream in order that it may contain the high percentage of fat. If the nurse and mother are careless or stupid it is impossible to rely on the directions being properly carried out.

Besides this, cream is liable to be acid and not to mix well with the milk.

4. No matter how much water is added for the purpose of dilution, the solid constituents bear the same proportions to each other as in human milk. Hence, if the child be weakly or atrophic, or if the digestive functions are impaired, the milk may be given in a diluted form without depriving it of any one constituent rather than another; while the deficiency in quality can be remedied by an increase in quantity.

TABLE LII.

Effects of Dilution of Cream Milk.

	Parts.	Parts.	Parts.	Parts.
Cream milk .	Undiluted	3	2	1
Water . .	nil	1	1	1
	per cent.	per cent.	per cent.	per cent.
Proteids . .	1·82	1·36	1·21	0·91
Fat . . .	3·70	2·78	2·46	1·85
Sugar . .	6·88	5·16	4·59	3·44
Salts . .	0·39	0·29	0·26	0·19

It is obvious that dilution with one part of water to three of cream milk renders the milk only equal in quality to a moderate specimen of human milk.

It is equally obvious on the other hand that, even diluted with one part of water to two of the milk, it is richer in fat than the average diluted cow's milk given to infants.

This milk possesses certain disadvantages which must be referred to. Although the total amount of proteids in the cream milk and human milk are the same, it must not be forgotten that the proportion of caseinogen to lact-albumin is much greater in the former than in the latter. Hence, the curd produced by the action of rennet ferment or acetic acid is not as fine as in the case of human milk. Comparative tests with acetic acid give these results:

(1) Ordinary milk . . .	Large coherent curd.
(2) Ordinary milk, *plus* water (equal parts) . . .	Small flocculent curd.
(3) Cream milk	Curd rather finer than (2).
(4) Cream milk, 2 parts, *plus* water 1 part . . .	Curd finer than (3).
(5) Cream milk 1 part, *plus* water 1 part	Curd finer than (4).
(6) Cream milk 1 part, *plus* water 2 parts	Practically no curd produced.

Thus it requires considerable dilution to render the reaction to acetic acid similar to that of human milk. This amount of dilution is equivalent to dilution of the original milk with four times its bulk of water and implies that the proportion of caseinogen is four times greater than in human milk. Another disadvantage is that, as the result of heating the milk to 160° F., it is partially deprived of its anti-scorbutic properties. This is far outweighed by the advantage gained from the destruction of the micro-organisms. In towns it is absolutely impossible to feed infants in warm weather on unboiled or un-Pasteurised milk without

grave risk, and even in the country it is not safe unless the cows are known to be perfectly healthy and the milk is obtained quite fresh. As a rule, the milk which reaches the consumer in London is at least twelve hours old. Centrifugalisation is not sufficient to render the milk non-injurious. I tried the cream milk on several infants without having it Pasteurised and it almost always caused vomiting. Other advantages are that the dangers arising from the use of dirty saucepans and the use of acid, or otherwise altered or contaminated, milk are avoided. The most unintelligent mother or nurse can prepare the food for the child, as it merely requires warming. A supply of constant quality is obtained without trouble, and comparatively slight increase in expense. Both time and trouble are saved.

The cream milk may be prepared by passing milk through a separator so as to divide it into two equal parts. Take the cream portion and add an equal quantity of a 9 per cent. solution of lactose or cane sugar in previously boiled water. Add sufficient bicarbonate of soda to render the mixture faintly alkaline and then Pasteurise in suitable bottles. The only objection to the use of cane sugar is that it renders the milk very sweet.

Cream milk may be prepared at home. Take a pint of good milk and add to it a like quantity of a 9 per cent. solution of lactose. Mix thoroughly and strain the whole into a clean vessel with a small hole, closed by a cork or a tap at the bottom. If it is then allowed to stand for an hour in summer or two hours in winter the cream rises into the upper half of the mixture. At the end of this time the lower

half should be drawn off and the remainder used to prepare the food for the infant. It will require boiling and must be made alkaline by the addition of a little lime water or bicarbonate of soda solution. In composition it compares favourably with good human milk. If it is found too rich for the child's digestion it may be slightly diluted. The process is a simple one and obviates the necessity of buying cream. It may be further simplified by using plain boiled water instead of the lactose solution and adding a teaspoonful of lactose or a lump of cane sugar to each feed. One drawback to the use of the lactose solution is that it decomposes readily. If the lactose is added subsequently the necessary proportion is a drachm to three and a half ounces of the milk.

Meigs recommends the following mixture. The elder Meigs found in clinical practice that a mixture of certain proportions of cream, milk, lime water and milk sugar was more adapted to the digestive capabilities of the average infant than anything else he experimented with. His son analysed the mixture and found that it contained the same amount of proteid as he found in average human milk. He then perfected the mixture according to the accompanying table:

TABLE LIII.

Meigs' mixture.	ozs.	Composition.		Human milk. (Meigs)
Cream 14–16 per cent. fat	2	Proteids	1·21	1·046
Milk	1	Fat	3·50	4·283
Lime water	2	Sugar	6·66	7·407
Sugar solution (lactose 17¾ drs. to water 1 pint)	3	Salts	0·25	0·101
	8			

The chief fault in this mixture is that it contains much more lime water than is necessary to render the milk faintly alkaline like human milk. Meigs' mixture is strongly alkaline and the taste of lime water is very perceptible; some infants do not like it. It can be demonstrated that in order to render average cow's milk of the same degree of alkalinity as human milk only one-eighth its bulk of lime water need be added.

In 1899 A. V. Meigs confirmed his previous observations that human milk never contains more than 1 per cent. of casein. He simplified his mixture thus:—A quart of good milk is placed in a high vessel and allowed to stand in a cool place for three hours. By pouring one pint slowly from this, without shaking, the upper part, rich in fat, is obtained. Mix this in the proportion of an ounce and a half to one ounce of lime water and an ounce and a half of sugar water (lactose 18 drachms, = eight heaping teaspoonfuls, to water one pint). He recommends as a suitable vessel a high cylindrical one made of tin with a hole, stopped by a cork, half-way down.

A somewhat similar mixture is recommended by Biedert, as follows:

TABLE LIV.

Biedert's Cream Mixture.		Composition.	
Cream	1 oz.	Proteids	1·8
Milk	1 oz.	Fat	2·7
Milk sugar	1 dr.	Sugar	3·8
Water	3 oz.	Salts	0·14

The chief faults of this mixture are that it is distinctly acid, rather deficient in fat and very deficient in sugar. The acidity can be counteracted by replacing half an ounce of the water by half an ounce

of lime water, and the amount of sugar can be easily increased.

Rotch has worked out a mixture on similar lines, taking into consideration and remedying the defects apparent in the preparations of previous observers. It is important to get cream of known richness in fat, as this is a fluid varying considerably in consistence according to the method of separation. The centrifugal cream of the large dairy companies contains about 20 per cent. of fat. Such is the cream to be selected, and it can be readily obtained in large towns. It is rather too rich in fat; and should be diluted one fourth, reducing the percentage of fat to fifteen.

TABLE LV.

Rotch's Mixture.		Composition.	
Cream (centrifugal cream, 20 per cent. fat, diluted $\frac{1}{4}$ or $\frac{1}{3}$)	2 oz.	Proteids	1·11
Milk	1 oz.	Fat	4·00
Lime water (diluted $\frac{3}{4}$)	2 oz.	Sugar	6·26
Milk sugar	$3\frac{3}{8}$ dr.	Salts	0·21
Water	3 oz.		
	8 oz.		

For the purpose of adding the proper amount of milk sugar, Rotch devised a simple tin measure, made to hold the amount required. This mixture fulfils all the requirements, and the only objections which can be urged against it are that it contains a comparatively low percentage of proteid and that the mode of preparation, as described above, is somewhat complicated. It can, however, be very much simplified, as follows:

TABLE LVI.

			Composition.	
Take—Cream (20 per cent. fat)	$1\frac{1}{2}$ oz.			
Milk	1 oz.		Proteids	1·2
Water	5 oz.		Fat	4·2
Milk sugar	1 measure		Sugar	6·5

Boil or steam this in order to destroy micro-organisms and, when it has cooled down to a temperature of 100° F., add half an ounce of lime water. The advantages of simplicity are so great that I have attempted to carry it still further and recommend the mixture to be made in the following proportions :

TABLE LVII.

			Composition.	
Take—Cream	2 parts			
Milk	3 parts		Proteid	1·1
Sugar solution	10 parts		Fat	3·3
Lime water	1 part		Sugar	6·7

The sugar solution can be prepared readily at home by dissolving an ounce and three-quarters of lactose (equal to two and a half ounces by measure) in a pint of boiled water.

Rotch has devised a method for the home modification of milk which is sufficiently valuable to be here reproduced. The essential apparatus consists of a wide-mouthed glass quart jar and a syphon of glass tubing, one-quarter to one-half inch diameter, bent so that the end out of which the milk has to flow is six inches longer than that which is inserted in the jar. One quart of fresh milk from a herd of cows is thoroughly strained and put in the jar, which is kept open for fifteen minutes in order to get rid of the animal heat. The jar is then sealed tightly, as in preserving, and placed in a vessel con-

taining ice-water and salt, in the proportion of a teaspoonful of salt to a quart of water, and set aside in a cool place for six hours. At the end of this period syphon the milk out in three portions. The lower fourth is practically fat-free milk. The middle half contains 2 and the upper fourth 10 per cent. of fat. To use the syphon fill it with clean boiled water, close the longer end with the finger, invert the syphon, and place the shorter end in the milk. Withdraw the finger, and the water followed by the milk will run out of the long arm of the syphon. The mouth must not be used to start the flow through the syphon.

The materials requisite for preparing the mixture consist of:

(1) The fat-free milk portion.

(2) The cream portion, containing 10 per cent. of fat.

(3) The 2 per cent. fat milk; less often required.

(4) Milk sugar. This may be bought by the pound, together with a tin measure containing $3\frac{3}{8}$ drachms, used to measure out the required quantity. Or it may be ordered in packages from the chemist; a pound (7000 grains), being divided into thirty-five packages of $3\frac{3}{8}$ drachms (200 grains) each.

(5) Lime water.

(6) Some clean drinking water which has been boiled for five minutes.

In order to prepare 20 oz. mixtures of definite percentages of proteid, fat, and sugar, the materials are mixed in the proportions given in the following tables, using the cream and the fat-free milk portions. The milk sugar is to be thoroughly dissolved

in the water of the mixture before the other materials are added.

TABLE LVIII.

1

Proteid	0·50	Cream	1 oz.
Fat	0·50	Milk	$\frac{3}{4}$ oz.
Sugar	4·50	Lime water	1 oz.
Lime water	5·00	Water	$17\frac{1}{4}$ oz.

Milk sugar . $1\frac{3}{4}$ measures.

2

Proteids	0·25	Cream	$\frac{1}{2}$ oz.
Fat	0·25	Milk	1 oz.
Sugar	4·00	Lime water	1 oz.
Lime water	5·00	Water	$17\frac{1}{2}$ oz.

Milk sugar . 2 measures.

3

Proteids	0·75	Cream	2 oz.
Fat	1·00	Milk	2 oz.
Sugar	5·00	Lime water	1 oz.
Lime water	5·00	Water	15 oz.

Milk sugar . 2 measures.

4

Proteids	0·75	Cream	4 oz.
Fat	2·00	Milk	None.
Sugar	5·00	Lime water	1 oz.
Lime water	5·00	Water	15 oz.

Milk sugar . 2 measures.

5

Proteids	1·00	Cream	4 oz.
Fat	2·00	Milk	$1\frac{1}{2}$ oz.
Sugar	5·50	Lime water	1 oz.
Lime water	5·00	Water	$13\frac{1}{2}$ oz.

Milk sugar . $2\frac{1}{4}$ measures.

6

Proteids	1·00	Cream	5 oz.
Fat	2·50	Milk	None.
Sugar	6·00	Lime water	1 oz.
Lime water	5·00	Water	14 oz.

Milk sugar . $2\frac{1}{2}$ measures.

7

Proteids	1·50	Cream	7 oz.
Fat	3·50	Milk	1 oz.
Sugar	6·50	Lime water	1 oz.
Lime water	5·00	Water	11 oz.

Milk sugar . 2½ measures.

8

Proteids	1·50	Cream	8 oz.
Fat	4·00	Milk	None.
Sugar	7·00	Lime water	1 oz.
Lime water	5·00	Water	11 oz.

Milk sugar . 2¾ measures.

9

Proteids	2·00	Cream	8 oz.
Fat	4·00	Milk	2½ oz.
Sugar	7·00	Lime water	1 oz.
Lime water	5·00	Water	8½ oz.

Milk sugar . 2½ measures.

10

Proteids	2·50	Cream	8 oz.
Fat	4·00	Milk	5 oz.
Sugar	7·00	Lime water	1 oz.
Lime water	5·00	Water	6 oz.

Milk sugar . 2¼ measures.

11

Proteids	3·00	Cream	8 oz.
Fat	4·00	Milk	7½ oz.
Sugar	7·00	Lime water	1 oz.
Lime water	5·00	Water	3½ oz.

Milk sugar . 2 measures.

12

(For weaning.)

Proteids	3·00	Cream	8 oz.
Fat	4·00	Milk	7½ oz.
Sugar	5·00	Lime water	1 oz.
Lime water	5·00	Water	3½ oz.

Milk sugar . 1 measure.

13

(For weaning.)

Proteids	3·25	Cream	8 oz.
Fat	4·00	Milk	8 oz.
Sugar	5·00	Lime water	1 oz.
Lime water	5·00	Water	3 oz.

Milk sugar . $\frac{7}{8}$ measure.

14

(For weaning.)

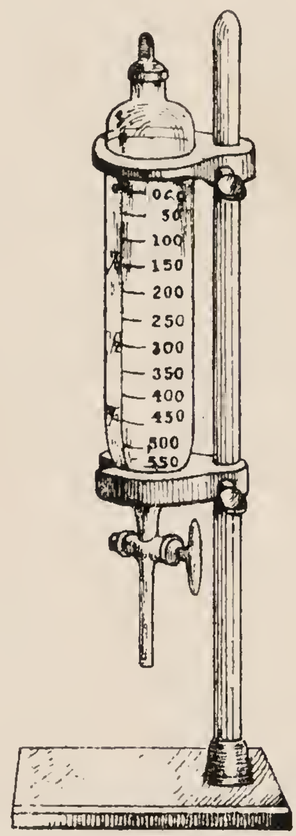
Proteids	3·50	Cream	8 oz.
Fat	4·00	Milk	12 oz.
Sugar	4·50		

A more satisfactory and simpler method of dividing the milk into the cream and milk portions devised by Rotch is to make use of a glass separating cylinder terminating at its lower end in a tubular prolongation closed by a glass tap. This must be graduated so as to divide it into four equal portions of five ounces each, or according to fancy (*vide* Fig. 1). The milk is poured in at the top end through a funnel, and a cork inserted. It is then put aside in a cool place, surrounded by ice in hot weather, and allowed to stand for three hours. To prepare the portions required the cylinder is filled up to the top graduated line. After standing, the lower three-quarters are removed by turning on the tap, and then the remaining quarter, the cream portion, into a separate receptacle.

The apparatus can also be used for preparing the cream milk recommended above (p. 166). It is filled up to the graduation mark and, after standing, divided into two portions, the lower or skim milk being discarded and the upper or cream milk used for preparing the infant's food. Cream milk prepared in this way merely differs from Gärtner's

"Fettmilch" in not having the foreign matters present in the milk removed by the centrifugal force, and in having a slightly smaller proportion of fat, the fat not completely rising into the upper half of the milk in the time allowed for separation.

Fig. 1.



Apparatus for separating milk; graduated in quarter pints and in cubic centimetres, divisions of 50 c.c. each. It is supplied by Messrs. Baird and Tatlock.

I can only speak generally of the value of "Fettmilch" as a food for infants. In the cases for which I have used it the children have made satisfactory progress. A children's hospital is not suitable for such observations. Either the child's illness, for which it is a patient, is of such a nature as to interfere with its nutrition, or the time during which the observation can be carried out is too short for very definite results to be obtained.

Keilmann has reported the results of some very careful observations made on newly born children at the Breslau Lying-in Hospital. Many of the infants were kept in a separate part of the building for the purpose, for weeks and months, some even for a year. The newly born child was weighed and washed and put to bed; it invariably went to sleep and was not offered its first meal until it showed signs of wanting nourishment. In artificial feeding the time and quantity of each feed were carefully noted by the nurse, and the child was weighed every morning

between seven and eight o'clock. The temperature was recorded and the number, colour, consistency and reaction of the motions.

In one series of experiments the milk was mixed with three times its amount of water, and 20 grammes of lactose were added to each litre. In a second series the milk was mixed with an equal quantity of water. Soxhlet's bottles were filled with the mixtures and boiled for forty-five minutes in a water bath. The food was prepared in the morning and evening, allowed to cool, and re-warmed before feeding. To the first mixture lime water was added. It was found that the addition of lime water did not improve the rate of increase in weight; it could even be shown that infants fed on the mixture containing lime water lost more weight during the first nine days of life than those which had no lime water in their food. The mixture containing the lime water was, however, much more diluted, but the average results show a much smaller loss of weight on the more diluted milk. He concluded that lime water did not exercise any particular influence one way or the other and might be left out of the calculation. It was very evident that infants fed on either of these mixtures did not progress as well as those fed at the breast. The percentage loss of weight on the ninth day amounted in 181 breast-fed infants to 1·7; in 39 infants fed on equal parts of milk and water to 6·1; in 56 fed on milk diluted with three times its bulk of water to 5·9; while in 45 infants fed on fat milk it only amounted to 3·82. Thus not one of these methods of feeding was equivalent to breast-feeding.

In the experiments with Gärtner's "Fat Milk," the

milk was prepared to contain 3·1 per cent. of fat; it was sterilised and cooled down as soon as possible after sterilisation; it was kept in a refrigerator until required for use, and warmed before administration. It was given undiluted. The results showed that the loss of weight on the ninth day was more than twice that sustained by the breast-fed infants, and more than half that of the infants fed on the diluted milk. Losing less weight in the beginning these infants showed better results in the end, and began to gain weight after the first "milk-stool." A greater loss of weight at first in infants fed at the breast, as compared with those fed on fat milk, is due to the milk secretion not being rapidly established. It is amply compensated by their more rapid subsequent growth.

A table, giving Keilmann's results in full, was published in the first edition of this work.

Some of the infants fed on the fat milk developed signs of dyspepsia, showing that the milk was not properly assimilated. Keilmann separated the results into groups according to the presence or absence of digestive disturbance. Twenty-seven were always perfectly healthy, eighteen showed passing symptoms of illness, and five were discarded as doubtful. The daily increase in weight, after the physiological decrease ceased, gave the following results:—

TABLE LIX.

Daily Rate of Gain according to the Method of Feeding.
(KEILMANN.)

For infants at the breast	32·8 grammes
For the healthy on fat milk	23·0 ,,
For the dyspeptic on fat milk . . .	9·3 ,,
For the infants fed on cow's milk . .	2·8 ,,

Therefore this preparation is more suitable for the infant, even in the presence of dyspepsia, than diluted cow's milk is for the healthy. Sufficient of this writer's observations have been quoted to show that fat milk is a valuable food for infants, much more so than the ordinary mixtures of cow's milk generally employed.

The value depends on three factors:—(1) The proportion of fat in the milk approximates closely to that in human milk. (2) The milk is purified by centrifugalisation and sterilisation. (3) The proportion of proteid is reduced below 2 per cent., the amount usually present in human milk.

Cream milk, prepared according to the method described on p. 161, has a similar composition and should give equally good results. If it is not satisfactory, the cause lies in the impurity of the milk before separation, the production of deleterious substances in it by the action of micro-organisms, or in the proportion of caseinogen. No matter how the preparation is made, there is more caseinogen in both fat milk and cream milk, than in human milk.

Other systems of home modification of milk have been devised by various writers. Some are valuable or, at any rate, useful. These are described shortly.

Holt's System.—Holt recommends that the relation of fat to proteid in the food should be as three to one during the first three months of life; as two to one from the age of three to nine months; after nine months in equal quantities.

According to his observations the upper third of a quart of milk, after standing four to five hours, will contain 10 per cent. fat and 3·3 per cent.

proteid. The upper half of milk under similar circumstances will contain 7 per cent. fat and 3·5 per cent. proteid. In whole milk the percentages of fat and proteid are alike.

Townsend's System.—For this we require top milk, sugar, water and lime water; and sometimes the residue of the milk. The top milk must contain 10 per cent. fat. Such a percentage is found in the top quarter of milk which has stood for six to eight hours. The presence of every ounce of this top milk in a 20-oz. mixture raises the percentage of fat 0·5, of sugar 0·2, of proteid 0·2. An even tablespoonful of lactose weighs three and a half drachms and the addition of this amount to a 20-oz. mixture gives 2 per cent. of sugar. For example:—

TABLE LX.

	Percentage.	Amount.		Amount.	Percentage.	
Proteid	0·80	4 oz.	Top milk .	8 oz.	1·60	Proteid
Fat .	2·00	15 oz.	Water .	11 oz.	4·00	Fat .
Sugar .	4·80	7 dr.	Sugar .	8¾ dr.	6·60	Sugar .
		1 oz.	Lime water	1 oz.		

Beginning with the weak mixture it is easy to pass gradually to the stronger one by the addition of an ounce of top milk and the subtraction of an ounce of water at a time. If it is wished to increase the proteid and not the fat some of the residue, from which the top milk has been removed, must be added instead of top milk.

If the upper half of milk which has stood from six to eight hours be taken it will contain 7–8 per

cent. of fat. Mixed with an equal quantity of water we get proteid 2 per cent., fat 3·5–4 per cent., sugar 2·2 per cent. With two parts of this milk to one of water the percentage of proteid is raised to 2·66, of fat to 4·6–5·3. In either case the required percentage of sugar is readily obtained by adding it to the 20-oz. mixture. The latter quantity is a very convenient one for the purpose of making the necessary calculations. The 8-oz. mixture also enables us to calculate percentages easily. The mixtures should be made twice a day, in a clean jug, poured in the amounts required for each feed into bottles, stoppered with cotton wool, and sterilised, pasteurised or kept in ice until used.

There is nothing new in the use of top milk. Over fifty years ago it was used by a doctor in Paris, at first diluted with two parts of water, and gradually less diluted, until at six months the child took a mixture of equal parts and at one year two parts of milk to one of water.

One disadvantage of the use of top milk is the variation in the amount of fat it contains. Moreover, the figures given by different writers do not correspond. Thus Chapin takes the top 9 oz. of a quart in order to get milk containing fat and proteid in proportions of three to one; and the top 15 oz. to get proportions of two to one. He recommends the use of the top 12 oz. as containing 12 per cent. fat.

Fortunately for the home modification of milk it is not necessary to know the exact percentages of fat and proteid which are present in the milk used. Provided always, that the same amount of top milk is taken after the same period of standing. From

the effect on the child, as judged more especially by the character of the stools, it is easy to decide whether more or less fat is required.

The Decimal System of Coit.—By this method it is comparatively easy within limits to start with a weak mixture and gradually increase it to a stronger one, *e.g.*, P. 0·5 – 1·66, F. 2·0–4·0. It is based on the assumption that the top portions of milk which have stood a definite period of time contain a fairly constant percentage of fat. Being based on such an assumption as this, it seems rather rash for Coit to claim, as he does, simplicity in calculations, flexibility in adjustments, and accuracy in results. The standard materials required are:—

1. Decimal Sugar Solution.—A solution of 1 oz. of lactose by weight in hot water to 10 fluid ounces. This contains 10 per cent. of sugar.

2. Decimal Cream No. 1.—The top 6 oz. of a quart of milk which has stood fifteen hours, *plus* 3 oz. of water, contains 10 per cent. of fat. The percentages of proteid and sugar are sufficiently accurately estimated as one-fourth of the fat.

3. Decimal Cream No. 2.—The top 11 oz. of a quart of milk which has stood for fifteen hours contains 10 per cent. of fat. The percentage of proteid is one-third and of sugar one-half that of the fat. This is used for the higher percentages of proteid.

4. An alkaline water.

The necessary data are the quantity of food and the percentage composition which it is desired to start with and to which it is desired to go.

Example.—To start with a food of composition P. 0·5, F. 2·0, S. 5·0, and raise it to P. 1·33, F. 4·0, S. 7·0 in a 20-oz. mixture.

$$\text{Decimal Cream No. 1}\left\{\begin{array}{l}\text{P. } 0{\cdot}5\\ \text{F. } 2{\cdot}0\\ \text{S. } 5{\cdot}0\end{array}\right\} 20 \text{ oz.} = 600 \text{ c.c.} \times 0{\cdot}2 = 120 \text{ c.c.} = 4 \text{ oz.}$$

$$\text{Sugar solution . . S. } 4{\cdot}5 \quad 20 \text{ oz.} = 600 \text{ c.c.} \times 0{\cdot}45 = 270 \text{ c.c.} = 9 \text{ oz.}$$

Hence the mixture must consist of 4 oz. of Decimal Cream No. 1, 9 oz. of Decimal Sugar Solution and 7 oz. of water.

Gradual advance in strength is secured as follows:—

	Amount in ounces.				
Cream No. 1 . .	4	5	6	7	8
Sugar solution . .	9	9	9	9	10
Water . . .	7	6	5	4	2

To obtain a mixture with P. 1·33, F. 4·0, S. 7·0 it will be necessary to mix together Cream No. 2 8 oz., sugar solution 10 oz., water 2 oz.

A Simple Method.—Once the initial difficulty of obtaining a superfatted milk of definite fat percentage is overcome, it is comparatively easy to devise weak mixtures and gradually to increase the strength.

The top half of good mixed milk which has stood from four to six hours will contain P. 4·0, F. 8·0, S. 4·0 percentages about. A mixture of 1 oz. of milk sugar, 1 oz. of lime water and water to 20 oz. will contain 5·0 per cent. of sugar.

Therefore if there be taken of the top milk amounts increased gradually from 5 oz. to 10 oz. and of the sugar solution sufficient to raise the total amount to 20 oz., the percentages in the first mixture will be P. 1·0, F. 2·0, S. 6·0, and in the last P. 2·0, F. 4·0, S. 7·0. Should it be desired to have a higher proportion of fat to proteid, allow the milk to stand a similar time and use only the top third.

ERRATUM (p. 182).

A Simple Method.—In this method the mixture must be made up to 20 oz., and then the ounce of sugar should be added. Or the strength of the sugar solution must be increased.

Laboratory Methods.—On the grounds of scientific accuracy and to minimise the chances of food contamination the system of preparing the food for infants in laboratories, in somewhat the same way as medical prescriptions are made up by chemists, has been largely adopted in America and to a less extent in this country. The Walker-Gordon Company of New York established a branch in London over seven years ago and milk mixtures are made up there according to the formulæ prescribed by the physician. Several of the large dairy companies will make up milk prescriptions in a similar way.

Sample of a milk prescription:—

To the IDEAL MILK COMPANY.

Percentages.		Remarks.
Proteid . . .	1·0	Number of Feeds, 8.
Fat	3·0	Amount of Each Feed, 2½ oz.
Sugar . . .	6·0	Alkalin

Pasteurise at 157°

For........................

Date...............

Signed.....................

Milk is delivered at the laboratory at a temperature of 40° to 50° F. The laboratory or modifying room is isolated, cool and free from dust. Walls and floors are kept wet. Clean garments are worn. Modifying materials are kept at 40° F.; a low temperature being found better than heat. The cream is separated by machinery in a separating room. A distilled water still and a Babcock's fat tester are required. The amount of fat in both

cream and milk is estimated daily. A 20 per cent. sugar solution, cream, fat-free milk, lime water and distilled water are the materials needed. After the food is mixed, according to the prescription, it is poured in the proper amounts into bottles. The bottles are stoppered with non-absorbent, aseptic cotton wool and are put in wicker baskets. The food is heated to the temperature required or is kept in ice. On the whole the best results are obtained when heat is not used, provided that the milk, from the time it leaves the cow to the time it reaches the infant, is kept at a low temperature. In percentage feeding, according to the above methods, the limits of the proteids are 0·25 and 4·0 per cent. and the fat can be reduced to 0·02 per cent. and raised to 40 per cent.

There are many advantages in percentage-feeding by laboratory methods. The milk is obtained from carefully selected cows, free from tuberculosis, and kept under the best of conditions as to food and hygienic surroundings. Special precautions are adopted, both for cow and milker, during milking. The milk undergoes careful subsequent treatment and is either kept at a low temperature, to prevent the development of micro-organisms, or raised to a high temperature to destroy them. The percentages of the different ingredients can be modified as desired and the food merely requires warming before being given to the child.

It is an immense saving of trouble to both doctor and nurse. It saves the doctor the trouble of writing out accurate directions as to the preparation of the food and the nurse the trouble of carrying out the directions. All that is required is a know-

ledge of the composition of milk and the little sense necessary to start with a weak mixture and gradually increase it. In fact, the matter is apparently so simple that the gradual modification of the food will pass, and already to a certain extent has passed, into the hands of the nurse and the laboratory official. The result of this is that there is created a new universal food for infants which appeals to the public on a pseudo-scientific basis.

On the other hand it must be pointed out that many cases do badly, and even very badly, on laboratory milk. Why this is so is not clear. Sometimes it depends upon faults in the prescription rather than in the milk itself. Often too low a percentage of proteid is persisted in for an unduly long time. Sometimes too much fat is given. Sometimes it is the continued feeding on a cooked food. Occasionally, in spite of the precautions taken, the milk has undergone decomposition by the time it reaches the baby.

The strongest argument against percentage-feeding lies in the fact that nature does not provide a milk of a definite, unvarying, chemical composition. Consequently it is quite unnecessary to get very close percentages and still more so to provide the same percentages in each feed. We have seen that the composition of milk varies at different times of the day and even in the different mammæ, as well as under numerous other conditions It is probable that there are many little indications for varying the composition of the food about which we are ignorant. Certainly the adult soon gets weary of the same food for meal after meal.

The child's stomach is not a test-tube, nor is the feeding merely of the nature of a chemical experiment. That the introduction of laboratory methods has done a large amount of good cannot be denied, for it has brought into prominence the importance of regulating the relative proportions of the different constituents in the diet. That it is necessary or even advantageous is by no means clear. Personally I have almost entirely given up laboratory methods in favour of a simple form of home modification. If we are dealing with milk and cream of percentages known within fairly close limits it is comparatively easy to devise mixtures suitable for the child. The variations in the composition of a mixed milk from day to day are usually very slight and probably advantageous rather than disadvantageous.

No matter what method we use in modifying milk we cannot alter the facts that the caseinogen of cow's milk is different from that of human milk; that the lactose and fats are probably not quite identical; and that a natural emulsion is more perfect than a re-combined one of centrifugal cream, water, &c. Although under a microscope the emulsions appear the same, if the two fluids are allowed to stand under the same conditions, the cream separates out much more quickly from the re-combined emulsion. Infants fed on the latter will often vomit water, fat, and curd quite separately.

In infants fed on laboratory milk all the common signs of malnutrition may be developed, *e.g.*, pallid and dry skin, flabby muscles, irritability, restless sleep, clay-coloured stools, and constipation. Sometimes acute gastro-enteritis is set up and occasionally scurvy. The latter disease is of slow development.

In one case, seen in consultation, the infant had been taking laboratory milk for ten months before the disease developed. The earliest case which has come under my notice was after five months of the diet. In both instances the milk had been pasteurised.

CHAPTER XI.

THE MANAGEMENT OF ARTIFICIAL FEEDING.

By artificial feeding is meant the hand-feeding of infants on some substitute which should correspond as nearly as possible with human milk. Before beginning it is advisable to put the alimentary canal in a normal condition, if there is any intestinal derangement. Do not begin while the child is suffering from a temporary attack of diarrhœa, unless the attack is due to some quality of the mother's milk which is likely to continue. The artificial mixture must contain a due proportion of the proximate principles of food, and should be given in amounts suitable to the physiological requirements and digestive capacity of the infant. These factors vary with the size of the child, its age and other considerations. Food deficient in one or more ingredients induces various disorders of nutrition, especially scurvy and rickets. It is of importance that the anti-scorbutic element should be present. This element is deficient in sterilised milk and in desiccated milk foods. Food must be given at regular intervals and care taken not to over-feed the child.

The principles, on which the rearing of infants by

hand is based, depend on the following considerations:

1. The size of the child's stomach. The age and weight of the child.

2. The quantity of food to be given at each feed.

3. The number of feeds to be given in the twenty-four hours.

4. The selection of a proper substitute for the breast-milk and the composition of such substitute.

5. The method of preparation of each feed.

6. The kind of bottle to be employed.

7. The temperature of the food.

8. The manner of administration of each feed.

9. The preservation of the food.

10. The cleanliness of all apparatus.

The Size of the Child's Stomach.—This varies considerably at different ages and in different children of the same age. As a rule the capacity in breast-fed infants is proportionate to the size of the child. It may be estimated by weighing the child immediately before and after the nursing; the difference in weight represents the weight of food taken in, and this corresponds closely with the capacity of the stomach. To obtain accurate results the mother must have a sufficient supply of milk, and the child must be perfectly healthy. The weighings must be taken at every nursing and an average result deduced. The weight of one feed is insufficient as a standard, on account of the variation in the child's appetite. If a large number of healthy infants are fed and weighed in this way, the average capacity of the stomach at different ages and the average capacity proportionate to the weight of the child can be estimated.

Experience has shown that the capacity is very variable even in children of the same age and weight. The results are, however, of considerable value for the purposes of artificial feeding.

The age alone is insufficient as a standard. A healthy, well-developed child is frequently able to ingest and digest more at a feed than an older, smaller, less developed one. No hard-and-fast rule can be laid down that at a certain age the stomach is of a certain size and will admit a certain definite quantity of food, neither more nor less. Infants, too, have their own peculiarities. Just as in adults, so in infants we find a considerable variation in the size of the stomach and the amount of food which can be taken and digested with advantage.

The stomach is very small at birth, and the rate of increase is not a constant one. It increases rapidly during the first two months of life and only slowly afterwards. Frowlowsky has attempted to form a table indicating the rate of increase:

TABLE LXI.

Rate of Increase in Gastric Capacity (FROWLOWSKY).

Age—week	1st	4th	8th	12th	16th	20th
Capacity in ounces	1	$2\frac{1}{2}$	$3\frac{1}{5}$	$3\frac{1}{3}$	$3\frac{4}{7}$	$3\frac{3}{5}$

Attempts have been made to estimate the size of the child's stomach by *post-mortem* measurement. Caillé's results were obtained in this way from seven children. The stomach was first thoroughly washed, then filled with water, and the contents poured out into a graduated vessel. No doubt the cause of death and the mode of feeding during life largely influenced the results, and there is great liability to error in the method of measurement adopted.

TABLE LXII.

The Gastric Capacity after Death (CAILLÉ)

Sex.	Age.	Disease.	Capacity of Stomach.
1. Male . .	5 weeks	syphilis	124 grammes
2. Female .	6 ,,	simple atrophy	31 ,,
3. Male . .	3 months	,,	39 ,,
4. Male . .	4 ,,	,,	249 ,,
5. Female .	5 ,,	,,	218 ,,
6. Female .	16 ,,	entero-colitis	140 ,,
7. Male . .	18 ,,	,,	467 ,,

These results show that the size of the stomach is very variable in different conditions of age and disease. *Post-mortem* measurements are often larger than those given by Frowlowsky. This is probably due to over-distension. Even if the latter observer has under-estimated the capacity, it is an error on the right side. The danger of giving too little food is infinitesimal, compared with the danger of giving too much. The consequences of too much food and over-distension of the stomach are constantly illustrated in the hand-fed infant, whose gastric capacity is generally increased beyond that of a breast-fed infant of the same age.

If the infant requires to be hand-fed from birth, its stomach capacity may be estimated as equal to one-hundredth part of its original weight and an increase of one gramme daily allowed up to the end of the first month.

Estimation of Gastric Capacity for the First Month, of a Child Weighing 3000 *gms.* = 6·6 *lbs.*

Age . .	1–7 days ...	8–14 days ...	15–21 days ...	22–28 days.
Weight of each feed	30 gms. ... (1 oz.) ...	37 gms. ... ($1\frac{1}{4}$ oz.) ...	44 gms. ... ($1\frac{1}{2}$ oz.) ...	51 gms. ($1\frac{3}{4}$ oz.)

Rotch made a series of observations on the gastric capacity of infants carefully fed on food from his milk laboratory. The children were all strong and healthy, and gained weight during the year the experimental feeding was carried out. A steady increase in gastric capacity was noticed, equivalent to about half to three-quarters of an ounce per month after the end of the first month :

TABLE LXIII.

Gastric Capacity of three hundred and forty-one Infants at the Milk Laboratory (ROTCH).

Age.	Number of cases for each age.	Average amount of food at each feeding.	
		c.c.	oz.
Birth	45	20·4	0·98
4 weeks . . .	76	70·5	2·35
8 " . . .	84	96·6	3·22
12 " . . .	97	118·8	3·96
16 " . . .	87	137·0	4·57
20 " . . .	86	158·4	5·28
6 months . . .	73	171·3	5·71
7 " . . .	56	185·4	6·18
8 " . . .	54	208·5	6·95
9 " . . .	45	226·2	7·54
10 " . . .	33	238·8	7·89
11 " . . .	28	242·0	8·07

In this table the same infant has been recorded a number of times at different ages.

The Quantity of Food to be given at each Feed.—A very important consideration is that a bulky food is not necessarily a nutritious one. A child lives and grows by the aid of the food which it digests and assimilates. Because a child takes a large quantity of food it does not necessarily

digest it, and the undigested portion may give rise to troublesome digestive disturbance and diarrhœa. The majority of hand-fed infants are over-fed; among the richer classes both as to quantity and quality; while among the poorer, the quantity is usually excessive, but the quality grossly deficient, especially in fat. The quantity to be given for a feed depends on the size of the stomach, and must be estimated from the weight of the child at birth or, if older, according to its age as illustrated in the last section. Allowance must be made for exceptionally fine or wasted infants. It is a difficult matter to decide how much food a child requires for each feed, and during the twenty-four hours. The only data we have to go on are the size of the child's stomach, the age and the weight. It has been shown that the child's stomach varies considerably at the same age, and bears no definite relationship to the age or weight in the case of hand-fed infants. Possibly in the healthy breast-fed infants a more definite relationship holds good, but here too we find much variation. According to the tables in the text the amount of food for each feed is determined according to the weight of the child at birth and, at a later period of life, when put on artificial food, according to its weight and age.

Several arguments can be urged against determining the amount of food by the age of the child. The marasmic infant six months old, yet weighing only six to seven pounds, does not require as much food as the vigorous healthy six months old child weighing two to four times as much. The child which has lost weight from illness does not necessarily require more food at the end of its illness

when it is older than it took at the beginning or before it was ill. Similarly the weight alone cannot be relied on as a guide. In the case of adults the amount of food taken and required does not depend on the mere weight of the individual. Animals do not require food in regular proportion to their bulk, but rather in proportion to their bodily activity. Thus for the infant who sleeps little, and actively moves and throws its limbs about, more food is required than for the lethargic child which sleeps most of the day and merely wakes to eat. Infants do not, however, vary much in respect to the extent of their muscular activity, so no great stress need be laid on this point. A fat rachitic child may weigh considerably more than a perfectly healthy one of the same age, but does not on that account require more food. It is evident that neither the age nor the weight alone can be relied on in order to decide accurately the quantity of food necessary for the child. From the two factors combined a fair estimate can be made, and the tables in the text are thus deduced from infants at certain ages and of average weights. The amounts must not be regarded as fixed and unalterable, but as suitable for the average child and requiring modification according to circumstances. These data afford a fair groundwork for formulating a diet suitable for any infant which comes under observation.

The best and only reliable indication that the child is properly fed, is a regular weekly gain in weight. If this is satisfactory the child is having sufficient nutritive food.

Apart from this the test of sufficiency is the satisfied condition of the child after it has been fed; it

will fall asleep until the next feed. Over-feeding is indicated by an irritable, restless, and wakeful condition from indigestion; constant crying, vomiting, the passing of curds in the motions, and attacks of diarrhœa or colic. Usually these symptoms are supposed by the anxious mother or nurse to be due to hunger. The child is fed whenever it cries, with temporary benefit from the ingestion of warm fluid, and the evil is thereby exaggerated.

The passage of normal motions is the most reliable proof that the child is properly digesting the food given, but it does not indicate that the food is sufficient in quantity.

My own observations have led me to the conclusion that the amounts recommended for each feed in Table LXIV. (p. 197) meet the requirements of most infants.

The Number of Feeds to be given in the Twenty-four Hours.—The same rules hold good as apply to breast-feeding. The number of feeds required in either method of rearing is the same, and they should be given at the same intervals. The younger the infant the more frequently it requires feeding. Artificial feeding is rarely necessary before the fourth day of life, and in the breast-fed must not be allowed, unless the child is a very feeble one, on account of the risk of diminishing the activity of suckling, the stimulation of the breast by suckling being one of the best stimulants to the secretion of milk. If the breast is not available from the time of birth artificial feeding should be commenced at once. There is no advantage to be gained by waiting and allowing the infant to lose weight. Some infants suitably fed will gain steadily

from the day of birth. During the first month the child is to be fed every two hours, from five in the morning to eleven at night. It is well to train the child to do without food during the six hours' interval at night. This allows the digestive functions a good rest, and enables the mother or nurse to obtain five or six hours' uninterrupted sleep. An extra feed may be allowed for very weakly infants during the night.

During the second month the child requires eight feeds at intervals of two and a half hours, from five in the morning to half-past ten at night; and an extra feed during the night in case of necessity.

After the second month the child only requires feeding every three hours, from five in the morning to eleven at night, a total of seven feeds in the twenty-four hours. Sometimes it is more convenient to give the first feed at six in the morning, and the last at twelve at night. Alterations in the time are of no importance, provided that the intervals between the feeds are not shortened.

The importance of regularity in feeding is so great that the child must be awakened if asleep when the feed is due. If it does not awake when the feed is due it is either a very weakly child, and ought not to be permitted to go for a prolonged period without food, or else it is being fed too well. In the latter case less food must be given for a meal, and the child will then awake in time for its next meal.

Some infants do not require feeding as often as seven times in the twenty-four hours after the age of six months. The number of feeds may be reduced to six, at intervals of three and a half hours, or, in some cases, to five, at intervals of four hours. Pro-

vided the child is thriving, digesting its food well, sleeping well, and gaining weight there is no objection to feeding it less frequently.

This mode of feeding is not to be encouraged, although it gives the nurse or mother rather less trouble. The prolonged intervals between the meals give rise to a ravenous hunger. The next meal is consequently taken too rapidly, and probably too much is taken at a time, with resulting over-distension of the stomach, colic, vomiting, and diarrhœa.

TABLE LXIV.

Time Table for Artificial Feeding.

Age.	Amount of each feed.		Total amount in 24 hours.		Number of feeds.	Intervals.
	oz.	c.c.	oz.	c.c.		hours.
1st week .	$1\frac{1}{8}$	32	$11\frac{1}{4}$	320	10	2
2nd ,, .	$1\frac{3}{8}$	39	$13\frac{3}{4}$	390	10	2
3rd ,, .	$1\frac{5}{8}$	46	$16\frac{1}{4}$	460	10	2
4th ,, .	$1\frac{7}{8}$	54	$18\frac{3}{4}$	540	10	2
2nd month	$2\frac{1}{2}$	70	20	560	8	$2\frac{1}{2}$
3–6 ,,	3–4	85–115	21–28	600–800	7	3
6–9 ,,	5-6	145-175	35–42	1000–1200	7	3

The above table gives a liberal diet, and one which is often taken with advantage by an ordinary child. If the child does not take the whole of any one feed the remainder must be thrown away. A little observation of the child and the character of the motions will show whether it is having too much food. Where a good nutritious food is available the amount for each feed may be diminished, but among the children of the lower classes the food is not of very good quality, and consequently more is required.

Moreover it is impossible to guarantee that the mother carries out the printed directions (see Appendix B), which I have drawn up for distribution to mothers who bring their infants to the hospital for treatment for digestive disturbance due to feeding. It is better to give a child a dilute food which it can digest than a richer food which disagrees with it, although the bulk of the latter may be smaller.

The Selection of a Proper Substitute and the Quality of such Substitute.—Enough has been written in previous chapters to show that the proper substitute for human milk is the milk of some other animal, so modified as to render it as nearly as possible like human milk. The milk of the cow is the kind employed on account of its low price and its wide distribution. The quality of the substitute must be such that it contains all the constituents of human milk in much the same proportion and in an easily digestible form. For this purpose the milk will require more dilution during the first two months of life than subsequently when the digestive power of the child has increased.

It is a common practice to increase the strength of the diluted cow's milk, employed as food, with the increasing age of the child. This is theoretically unsound. Mother's milk does not become richer as lactation advances. It does increase in quantity. Once the flow of milk is well established, the quality remains practically the same, within small limits, unless there is some general or local disturbance of health. In practice it is generally found that after the age of two months the infant can digest cow's milk diluted with an equal quantity of water, the

percentage of proteid being thus reduced to two or under.

In exceptional cases I have found it necessary to dilute the milk with as much as seven or eight times its bulk of water, in order to gradually accustom the infant to take cow's milk. By starting with a sufficiently diluted mixture this result can always be attained. I have had many infants brought to me on account of wasting or digestive disturbance, whose mothers have asserted that they cannot take cow's milk in any form whatever. With the rarest exceptions, and those only in the cases of extremely marasmic infants who could retain hardly anything, all these children have learnt to take the milk, properly diluted and in suitable quantities at the usual intervals. It is perfectly marvellous what some mothers give their children and yet expect that they will grow up strong and well.

The advantages of undiluted milk over the diluted mixture were urged by Parrot in 1887, and have been supported by Budin and Chavane, of Paris. The results obtained by them by feeding infants on sterilised undiluted cow's milk are very satisfactory. Prolonged heating at a high temperature renders milk less readily coagulable by rennet. Probably the good results obtained by these French doctors are due to this cause and the administration of small quantities at a feed. Although these observers claim better results from this mode of feeding than where diluted milk is given, it does not seem reasonable to give comparatively a large excess of proteid and a deficiency of sugar when both defects can be easily remedied. Diluted milk is naturally inferior to the undiluted fluid by reason of the

deficiency in fat. If the infant takes as much undiluted milk as it would take of breast-milk, it will have to dispose of a large excess of proteid. The amount of sugar in its food will be deficient, and we have no evidence that proteid can replace sugar in the diet with advantage.

The substitute foods used for artificial feeding have been referred to already and are here collected for the purposes of ready reference and comparison :

1. *Cream Milk.*—Prepared by adding an equal quantity of a 9 per cent. solution of lactose to cow's milk and passing the mixture through a centrifugal separator, so arranged that the two outgoing streams are equal. Or prepared in a similar way, using sterile water instead of the lactose solution and adding 4 per cent. of lactose or cane sugar subsequently. Or prepared by allowing a mixture of equal parts of milk and previously boiled water to stand in a suitable vessel or apparatus (*e.g.*, Fig. 1) for three hours, then drawing off and discarding the lower half and adding the requisite amount of sugar to the remainder (pp. 161–167).

2. *Gärtner's "Fettmilch."*—Prepared by passing milk and sterile water through a separator, so arranged that the outgoing streams are equal, the percentage of fat in the fat portion being regulated to 3·1 and milk sugar being added (p. 160).

3. *Rotch's Mixture.*—Cream (definite percentage of fat) 2 parts, milk 1, diluted lime water 2, milk sugar solution 3 (pp. 163, 169).

4 *Author's Mixture.*—Cream 10 parts, milk 30, lime water 10, water 30, milk sugar 4 (pp. 163, 170).

5. *Meigs' Mixture.*—Cream 2 parts, milk 1, lime water 2, milk sugar solution 3 (p. 167).

6. *Biedert's Cream Mixture.*—Cream 1, milk 1, lactose $\frac{1}{8}$, water 3 (p. 168).
7. *Home Modifications by Rotch* (p. 170).
8. *Holt's System of Modification* (p. 178).
9. *Townsend's System* (p. 179).
10. *Decimal System of Coit* (p. 181).
11. *Simple Method of Home Modification* (p. 182).
12. *Percentage Feeding by Laboratory Methods* (p. 183).

Reference to these various mixtures will enable any one with a moderate degree of intelligence to devise a food suitable for the particular child, according to its age, weight and digestive capacity.

For use among the class of hospital patients I have devised a simple mode of preparing mixtures suitable to the age of the child. The mixtures are very deficient in fat, unless the cream is added as recommended, but if the milk, from which the feed is prepared, is allowed to stand for two or three hours and the top part taken, a fair proportion of fat is obtained.

TABLE LXV.

Artificial Feeds devised for the Use of Hospital Patients.

Age.	1st week.	2nd week.	3rd week.	4th week.
Milk . . .	2	3	4	5
Cream . . .	1	1	1	1
Water . . .	5	6	7	8
Sugar . . .	1 lump	1 lump	1 lump	1 lump
Lime water .	1	1	1	1
	$1\frac{1}{8}$ oz.	$1\frac{3}{8}$ oz.	$1\frac{5}{8}$ oz.	$1\frac{7}{8}$ oz.

The amounts are given in teaspoonfuls. The lime water must be added after boiling the mixture. If cream cannot be obtained, give an extra teaspoonful of milk, taken from the top.

The proportion of proteid in these mixtures ranges between 1·0 and 1·5 per cent. The proportion of fat varies considerably with the quality of the milk and the cream used; it ranges roughly between 2 and 3 per cent. The degree of dilution is:

During the first week	3 in 9
During the second week	4 in 11
During the third week	5 in 13
During the fourth week	6 in 15

Ten feeds are given daily at intervals of two hours.

TABLE LXVI.

Diet for the Second Month.

Boiled cow's milk . . .	2 tablespoonfuls
Boiled water	2 ,,
Cream	1 teaspoonful
Sugar	1 lump
Lime-water	3 teaspoonfuls

A total of two and a half ounces; eight feeds at intervals of two and a half hours. It contains about 1·5 per cent. of proteid and 2·5 per cent. of fat.

TABLE LXVII.

Diet after the Second Month.

	Age 2–6 months.	Age 6–9 months.
Boiled cow's milk .	3-4 tablespoonfuls	5–6 tablespoonfuls
Barley water . .	3–4 ,,	5–6 ,,
Sugar . . .	1 lump	1 lump

Cream in the amount of 1–4 teaspoonfuls can be added to each feed with advantage. If cream is

not added, the child will require cod-liver oil. Seven feeds are to be given at intervals of three hours.

I have found these diets eminently satisfactory in the cases where the mother has the intelligence and will take the trouble to carry out the directions. A suitable bottle is necessary and a good supply of milk, fresh and not preserved by the addition of chemicals, and a due care that the vessel in which the milk is boiled and that the bottle and its appendages are kept properly clean.

The Method of Preparation of Each Feed.—This varies considerably with the variety of substitute food used and the time of year. If Gärtner's fat milk, or cream milk, be used, or if the percentage-system of feeding be adopted, and the food be obtained ready for use from a milk laboratory, all that is necessary is to measure out the requisite amount for a feed into a suitable bottle and warm it. It is even better that the milk should be supplied in small bottles, each containing sufficient for a feed. If poured out of a larger bottle it should be inverted gently two or three times to mix it, otherwise the cream may rise into the top portion and the composition of the different feeds will vary. As soon as the amount required is poured out the bottle must be re-stoppered or covered up and kept in a refrigerator or in a clean cellar, in a larger vessel containing ice-water. In preparing the feeds by the various other methods recommended in the text, the amounts of cream, milk, and water required for the twelve hours must be measured out in a measure glass graduated in drachms and ounces, or in cubic centimetres. The ordinary spoons may be used if

a proper measure-glass is not available, but they vary considerably in size and must not be regarded as accurate measures. The amount of milk sugar or cane sugar to be added is dissolved in the water and the whole thoroughly mixed.

Pour out from the vessel into a clean milk saucepan the quantity for the meal and heat the whole until the water in the saucepan has boiled freely for five minutes. It is perhaps enough just to "scald" the milk, that is, remove it from the fire as soon as it begins to boil; or even to stand it in boiling water for ten or fifteen minutes. The best kind of saucepan is one consisting of a porcelain lining fitted into a larger vessel containing water. A patent saucepan, made of tin, has been brought out under the name of Aymard's Patent Milk Steriliser. In principle it is the same as the ordinary milk saucepan, as described, but it possesses certain advantages, although it does not carry out all it professes to. The chief advantages are that it is made of tin and can therefore be cooled down rapidly without the risk of breaking, and it has a spout. After boiling, the milk must be cooled down rapidly to the required temperature and poured into a clean feeding-bottle. Then add the lime water or bicarbonate of soda solution, put on the teat and give it to the child.

The remainder of the mixture must be put aside, tightly sealed up, and kept in a refrigerator.

In towns, especially in hot weather, it is advisable to boil the whole of the mixture at the time it is prepared and to boil each feed again before administration. If the food is prepared in bulk, for a period of twelve hours, it must after boiling be put in a clean, tightly sealed glass jar and kept in a cool, clean

place, surrounded by ice-water, or in a refrigerator. The amount required for each feed must be taken out, after thoroughly stirring with a clean glass rod, and the jar again sealed up. A simpler method is to prepare all the feeds for the ensuing twelve hours from the materials as soon as received. Make the mixture as desired, pour sufficient for each feed into clean bottles of suitable size, such as Soxhlet's feeding-bottles, or small soda-water, or even six-ounce medicine bottles, plug the mouth and neck of each bottle with a plug of clean, previously baked cotton-wool, and put them in a boiler, supported in a suitable wire framework on the principle of a cruet stand. Pour water into the boiler until it reaches the level of the milk in the bottles and steam for half an hour to an hour on the fire. Then set aside to cool, and when cool remove the stand and bottles into a refrigerator or a cool cellar. For each meal take one bottle, warm it and add the alkaline solution, put on the nipple and give it to the child.

This and other methods of preparing the food will be referred to subsequently in discussing the various methods of sterilisation.

It is important to remember that once boiling milk is not sufficient to preserve it at ordinary temperatures. Boiled milk in an ordinary nursery, merely covered up with muslin to keep off the dust, will go sour almost as quickly as if unboiled. This is especially the case if the milk has not been cooled down quickly. All milk for the infant's use in hot weather must after boiling be kept tightly sealed up, as in jam preserving, in a cool place. Even with this precaution it must be again boiled before administration. This is not necessary when it is

steamed in bottles plugged with cotton-wool; the wool acts as a filter and keeps out the micro-organisms which cause the souring or other fermentative change.

The Kind of Bottles to be used for Feeding.—The bottles should be made of transparent flint glass and as free from angles as possible. In capacity each should not exceed ten ounces, the best size contains eight ounces. The simpler in construction and the fewer the component parts, the better is the kind of bottle. Two chief varieties are in common use. One has a long rubber tube attached to a glass tube inserted into the bottle and with a rubber nipple or teat at the other end for a mouthpiece. The other is boat-shaped, with a simple rubber teat fixed on at the orifice at one end and a round opening on one side, closed by a cork, for the insertion of the food. These two varieties are so well known that no further description of them is necessary.

The boat-shaped bottle presents many modifications, according to the fancy of the maker. The simplest form is that formerly in use in America, consisting of a spindle-shaped flask of blown glass with nipple and flange at one end and a lateral opening one inch in diameter for the admission of the milk. It was made all in one piece and no nipple was necessary. The action of gravity did away with the need of much suction power. A bottle resembling this, except in not possessing flange or nipple, and therefore requiring the addition of a rubber nipple, is in use in this country. I have devised a modification of this; the mouth is made wider, sufficiently so to enable the bottle to be cleaned with a bottle brush, and not too wide to admit of a

proper reversible rubber teat being affixed. Another variety is similar in shape, but has no lateral opening; the mouth is wide and closed by a glass screw, through which passes a glass tube with a rubber nipple and bone flange attached to it. A thin rubber band passes round the screw to enable it to be fixed in tightly, as in the ordinary screw-stoppered beer bottles. A better modification is one sold by Allen and Hanbury. It has a wide orifice at each end to enable it to be readily washed by running a stream of water through it. One end is closed by a rubber air valve, and to the other is attached a plain soft rubber teat. It is graduated. The air valve is not essential, and may be replaced by a solid rubber stopper or clean cork. Budin's Galactophore is a modification of the bottle with a long tube. It is only mentioned in order to be condemned as severely as all bottles which have a rubber tube of any length as part of their construction.

The disadvantages of the tube are serious. It is very difficult to keep it clean, especially in hot weather. Particles of milk stick to the sides and in the cracks, that develop in course of time, and there decompose. Glass tubes are similarly objectionable. Any one who has washed out a glass test-tube containing milk will appreciate the difficulty. The decomposing milk infects all the food taken and is a fruitful source of diarrhœa. Even with the careful use of a brush to clean the tube and antiseptics to keep it in, the risk is considerable. When such precautions are not available or are not carried out, decomposition invariably takes place and the tube has a characteristic sour smell.

The only advantage of this kind of bottle is that

it saves the mother or nurse a little trouble at the meal time. The nipple can be put in the child's mouth, and the child left to suck without supervision until the bottle is empty. A natural consequence of this is that the bottle is filled and given to the child to take as much as it likes, and subsequently the child has the tip put in its mouth to suck at whenever it cries. There is no regulation as to the amount of each feed or the intervals between the feeds. Often the milk goes sour in the bottle or gets cold long before it is all taken, and yet the unfortunate child has to take it and gets no fresh food until that bottle is imptied. Many mothers tell me they only feed the child twice or three times a day, and on inquiry it is almost invariably found that this is the method adopted.

The boat-shaped bottle is more inconvenient in that it requires the constant supervision of the mother or nurse during administration. On the other hand it is much more easily kept clean. There is no rubber tube to retain decomposing milk, and if a proper rubber tip is used it can easily be everted and scrubbed. Whichever kind is used care must be taken that the holes in the tip are of a suitable size; if too small the child may not be able to draw it properly, and if too large the food may run too easily, with the result that the child takes it down in great gulps and vomiting is induced. A circular orifice through which the food flows drop by drop, when the bottle is inverted, is the best.

A soft rubber tip such as is illustrated in Fig. 6 (p. 241), and sold with Soxhlet's bottles or separately, is the best kind to use. It is made of pure rubber and can be readily turned inside out. It should be

adapted in size to the infant's mouth and should be often renewed. After use it should be well cleaned and kept in cold distilled water or soda and water, until wanted.

Soxhlet's graduated bottles, soda-water bottles, medicine bottles, or indeed any other kind of bottle can be used with these tips as long as the mouth is small enough to permit the tip to be fixed on it. By making a good sized cross cut in the end of the tip, or a circular hole with a hot hat-pin, the child will have no difficulty in drawing the milk. The leech-bite orifice is not always satisfactory. It is advisable to have two bottles and two tips, and to use them alternately.

The Temperature of the Food.—The temperature of human milk ranges between 99° F. and 100° F. The artificial substitute should therefore be warmed up to this temperature. The simplest and best way is to place the bottle, containing the food, in a tin mug half full of hot water for five minutes. Take the temperature of the water at the end of that time, and if it is between 100° F. and 102° F. the food will be of a suitable temperature for administration. A little practice will enable the nurse to judge how hot the water should be to start with. Any method of determining the temperature of the food by dipping in the little finger, or by taste, must be rigidly avoided. Not nearly enough attention is paid to the temperature of the food in artificial feeding, often it is too hot and at other times too cold. Frequently it is of a suitable temperature at the beginning of feeding and almost cold before it is finished.

The Method of Administration of each

Feed.—The child should be half reclining on the nurse's lap with its head and back supported. A boat-shaped bottle of some sort must be used and at first held almost horizontally; it must then be gradually tilted up so as to keep the nipple full and thus prevent the swallowing of air. It is advisable to take away the bottle occasionally for a brief breathing-space and to prevent the child taking its food too rapidly. Allow ten to twenty minutes for each feed. Never allow sucking at an empty bottle or at one of those abominations, known as "Job's comforters." The latter are a constant source of flatulence and indigestion, whether of solid rubber or perforated, and being frequently dropped out of the mouth on to dirty clothes, carpet or floors, and as frequently replaced, are a potent source of mischief by conveying particles of dirt and micro-organisms to the child's mouth and alimentary tract. It is absolutely unnecessary that the infant should ever be taught the use of one of these abominations, which by no means improve the child's appearance or the development of its mouth. Some writers have gone so far as to assert that the use of these instruments is one of the chief causes of adenoid vegetations in the naso-pharynx. Another practice which ought to be strongly discountenanced is that of giving the child the finger to suck and letting every casual visitor put her finger in the mouth, because it pleases the child and keeps it quiet. Few fingers are scientifically clean and most are the very reverse. The mother and nurse should clearly understand that a healthy child does not cry unless it is hungry or requires its napkin changing. Many cry from indigestion, but that can hardly be considered a sign of health.

After the child has been fed it should have its mouth gently washed out with a soft handkerchief dipped in clean boiled water to remove the particles of milk sticking to the lips and gums. It must then be put quietly in its cot and allowed to sleep. It must not be jogged up and down on the knee unless the nurse wishes to make it vomit; in fact this method of nursing a child ought not to be allowed under any circumstances. Gentle swaying movements from side to side are the proper ones to adopt for soothing the child. The frequent jogging up and down may quieten the child, deadening its nervous system by the recurrent series of shocks applied to it.

The Preservation of the Food.—All food for the use of the infant must be as fresh as possible, nothing that has undergone the least putrefactive change is allowable. It should be stored in clean, sweet-smelling, cool places, and protected from access of air. A refrigerator in a clean cellar is the best place. If this is not available it may be kept in a tightly-corked bottle in cold or iced water. On no account is it to be kept in the nursery or bedroom, as a lazy nurse is so apt to keep it, because it is handy. Sometimes it is kept outside the bedroom door, and I have known of it being kept in a lavatory. Milk must never be kept where it can possibly be contaminated by smells from drains or housemaid's sinks, or decomposing food or animal matter. Further directions are given in the section on the preparation of the food, and in the subsequent chapter on the micro-organisms in milk, and the methods of sterilisation.

The Cleanliness of all Apparatus.—This is a point of great importance and one that is usually

carried out satisfactorily in a well-managed nursery. A bottle brush is necessary. Every bottle after use must be washed out thoroughly in hot water, and then in soda and water; after that it must be rinsed out several times in clean boiled water, hot or cold, and put in a basin in an antiseptic solution, or in clean cold water, until next required. Before use it must be again rinsed out in pure boiled water. All tips and, where used, other apparatus connected with the bottle must be treated in a similar way. The tip should be turned inside out and well scrubbed with a clean soft tooth brush. The cheapest antiseptic to use, and also a very satisfactory one, is boric acid in the proportion of a heaped teaspoonful to a pint of boiled water. Salicylic acid may be used instead, if preferred. It is advisable not to use carbolic acid or perchloride of mercury, or any strong-smelling disinfectant; there is no need to turn the nursery into a minor kind of hospital. Apply the nose to both the bottle and tip before use to be sure that there is no sour smell. The nurse must wash her hands after changing the napkins, and, in addition, must invariably wash before preparing and administering each feed. Many of these details are left to the nurse, and if she is a well-trained intelligent woman she carries them out. An old nurse is generally prejudiced, and thinks such details are unnecessary and unimportant. Even if she carries them out she does it without spirit, grudgingly and inaccurately. For this reason I much prefer a younger, active woman who has the sense to acknowledge that she does not know everything. No matter what kind of nurse is employed the mother is not justified in leaving all the details

and management of the child to that nurse. It is the mother's, not the nurse's, child, and she alone is responsible for its welfare. It is not enough for the mother to say that she pays a nurse good wages and expects to be relieved of all responsibility and anxiety. No nurse, however experienced and well-intentioned, will devote the same loving care to the child as its own mother. If the nurse sees that the mother does not clearly and definitely supervise the management of the child, there is even more risk of the attention devoted to it being slackened. If only every mother would believe that nurses are not perfect, even though the particular one is her own servant in whom she has every confidence, how much better it would be for the child. Every mother should clearly and decidedly take the direction of the nursery under her own immediate control, and by frequent irregular visits see that her directions are adequately carried out.

All the surroundings of the child, the nursery, bedding, furniture, &c., must be kept scrupulously clean. The nurse and her garments, not only those visible to the eye, must be clean. All diapers and dirty vessels must be removed at once from the room, and the room must be kept well ventilated. There is no better test of excellence of the nurse than the cleanliness of herself, the baby and the nursery, and the fresh sweet smell of the apartment, no matter what time the visit is paid. A special visit at any fixed time will not give this information, as all preparations will have been made for it.

CHAPTER XII.

THE MICRO-ORGANISMS IN MILK AND THE METHODS TO BE EMPLOYED FOR THEIR DESTRUCTION.

It has been shown that human milk is a sterile fluid, containing no micro-organisms, under ordinary conditions of health. A slight reservation must be added to this statement, namely, that a few microbes are often found in milk first secreted. This is due to the entrance of the microbes into the ducts of the nipple and there multiplying. They generally are varieties of staphylococcus (*vide* p. 84).

Cows' milk is sterile when obtained direct from the udder of a healthy cow by means of a trocar and cannula. Rigid antiseptic precautions must be used in the process of tapping.

If the udder and teats of the cow and the hands of the milker are well washed in an antiseptic solution, it will be found that the milk obtained during the second half of the milking is sterile while that first poured out contains various micro-organisms. These have made their way into the ducts of the teats from the outside. Subsequently many microbes get into the milk from the surrounding air, from the water used in washing the milk cans, and other sources. Microbes find in the

milk a suitable nutrient medium and multiply with great rapidity. Sedgwick and Batchelder give the following numbers as illustrative of the enormous crowds present in the milk reaching the consumer:

(1) 67,143 per cubic centimetre in samples of milk from the tables of persons in the suburbs of Boston. An average of fifteen examinations.

(2) Over 250,000 per cubic centimetre in milk taken direct from the milk carts in Boston. An average of fifty-seven examinations.

(3) Over 4,500,000 per cubic centimetre in the milk obtained from the Boston groceries.

In milk obtained from milk shops in London in 1896, the number was also enormous, varying from 848,400 to 8,119,200 per cubic centimetre. Renk found from six to thirty million per cubic centimetre in the milk supply of Halle.

The numbers present depend to a great extent upon the attention and care devoted to the process of milking, the cleanliness of the milk cans and the hands of the milker, the purity of the water used in washing the cans, the subsequent management of the milk, and the external temperature. No amount of care will prevent contamination, but the degree of contamination is less the greater the attention paid to cleanliness. The County Council might add to its reputation by stopping the sale of milk containing more than a certain number of microbes, say, 100,000 per cubic centimetre.

The longer milk is kept the greater is the liability to changes in its composition as the result of microbial growth and, apart from these changes, the further does it become removed from its character as a biologically living fluid. Unfortunately the

milk-supply of a large town is generally about twelve hours old, and crowded with microbes. Three main groups are found:—(1) Lactic acid forming; (2) Butyric acid forming; (3) Peptonising. The bacillus subtilis, bacillus mesentericus, and bacillus butyricus may all act on casein. The most common variety of fermentation is the acid fermentation leading to the souring of the milk. It is generally due to the lactic acid bacillus, though other organisms are at times the cause. There are about twenty varieties of microbes which cause this type of fermentation. The acidity of milk is a fair test of the number of microbes present and the care taken in its management. Some microbes produce coagulation of the milk without giving rise to the formation of acid. Another form of fermentation renders the milk viscous and unwholesome; on pouring it out from one vessel to another it is drawn out into coherent threads, and may thus be easily recognised. It is due to several micro-organisms, *e.g.*, a micrococcus (Schmidt-Mülheim), or the bacillus lactis viscosus of Adametz. All forms of fermentation can be delayed by cooling the milk as soon as it is drawn from the cow, a low temperature being inimical to the growth and multiplication of micro-organisms.

The lactic acid bacillus and many other varieties of microbes present in the milk are comparatively harmless organisms, and may even be beneficial by preventing the development of other species. Others are of uncertain value. Brieger has found in the fæces in large numbers a bacillus which ferments sugar and decomposes albumin; and a micrococcus which converts glucose and saccharose

into ethyl alcohol. It is by no means uncommon for pathogenic organisms to be present, The bacillus coli is almost universally present in London milk. Its presence does not, however, prove the occurrence of fæcal contamination as has been maintained by some authorities. If present in large numbers it indicates the possibility of such contamination, but the organism is so widely distributed that the appearance of one or two colonies in the cultures made from the milk, unless made from very diluted samples, is not of very great importance. Red milk is due to the growth of the bacillus prodigiosus in it. Blue milk is due to the bacillus cyanogenous. Yellow milk has been traced by Schröter to the bacillus synxanthus; by List to a species obtained from the fæces of sheep; by Adametz to a species found in cheese.

Several epidemics of enteric fever have been traced to the milk-supply. The milk becomes infected through the washing of the cans in infected water, through the illegal addition of infected water to the milk, or directly with the specific infection from man. Cholera may be spread in a similar way. Epidemics of scarlet fever and diphtheria have also been traced to an infected milk-supply. The former may be spread by particles of desquamating epidermis passing into the milk from the hands of a milker recovering from an attack of the disease, which may have been so mild as not to have been recognised. Or the cows may be affected with a disease, standing in some definite relationship to scarlet fever, in the form of an eruptive affection of the udder, as in the Hendon epidemic. Diphtheria may be spread by infection of the milk from

an antecedent case in the human subject, or as a result of a definite disease in the cow. Foot-and-mouth disease may also be communicated to human beings through the milk-supply.

Tuberculosis and Milk.—Since the discovery of the tubercle bacillus in milk and the flesh of diseased animals, it has been accepted as a fact that tuberculosis is spread very largely by the ingestion of infected food. This is supposed to be more especially true of infants and young children for reasons which may be stated shortly as follows:

(1) A very large amount of cow's milk is infected with the tubercle bacillus.

(2) Infants and young children take milk as the main article of their diet.

(3) The mortality from tuberculous affections has diminished largely among adults, but among infants there is no such decrease. This is shown by the large number of deaths recorded as due to tabes mesenterica.

Consider these statements in detail. It may be granted that tubercle bacilli, or bacilli resembling them, are frequently found in milk in small numbers. Staining methods are insufficient for diagnostic purposes. According to Möller there are nine acid-resisting bacilli which resemble the tubercle bacillus. Of these the butter bacillus is most likely to be a source of error in the case of milk. These bacilli cannot be distinguished microscopically. They have been found in milk, in the udder, in the intestines of healthy and tuberculous cows, in the dung, and in the Timothy grass sometimes used for fodder. The only conclusive test is the result of inoculation into guinea-pigs.

Milk is certainly the staple article of diet during the first year or more of life. For hand-fed children cow's milk is usually employed, especially among the better classes. Yet tuberculous abdominal lesions are not very common. They are more common among the poor than the rich, although, or perhaps because, the former get less milk. In addition, the milk obtained by the poor is more likely to be poorer in quality, cheaper, and perhaps infected. Among the better classes more care is taken in obtaining and preparing it. Among the poor all the factors, predisposing to tuberculous infection, are much more potent. But I can find no indication that a higher percentage of children fed on cow's milk get tuberculosis than of those fed on condensed milk. I regard children fed on condensed milk as much the more susceptible.

According to the Reports of the Registrar-General the mortality from tabes mesenterica is even increasing among infants. In spite of it having been pointed out by numerous expert pathologists that under the name of tabes mesenterica are included cases which have no connection with tuberculosis, the disease is generally regarded as tuberculous. Tabes mesenterica is very rare among infants. There is little doubt that almost all the cases so entered in mortality statistics, as occurring in infants under one year of age, are neither more nor less than the interesting disease known to the public by that blessed name "consumptive bowels," that is, diarrhœa and wasting due to improper feeding and ending in death.

Further there is strong evidence in favour of the view that tuberculous infection takes place through

the respiratory system rather than by the alimentary tract. In no less than twenty-three out of twenty-five cases dying under my care from tuberculous meningitis, one or more of the mediastinal glands were found to be caseous, most frequently the pre-tracheal gland. In only four of these instances were the mesenteric glands caseous.

The identity of the bacillus of human with that of bovine tuberculosis has also been called in question. Morphologically they differ slightly (Klein, Virchow, &c.) Koch has definitely stated that the bacilli are different; that the human bacillus will not give rise to bovine tuberculosis; and that the bovine bacillus will not give rise to human tuberculosis. From this he argued that tuberculous milk is harmless. He supported his views by asserting the infrequency of primary intestinal tuberculosis in infancy and by the absence of wide-spread epidemics due to the milk of tuberculous cows. Biedert found primary intestinal disease in only sixteen out of 3104 cases. Baginsky found no instance of such disease in 933 cases, unless the lungs and bronchial glands were also affected. Koch's statements have created an enormous amount of controversy, and the matter still remains *sub judice*.

The transmission of tuberculous disease to animals by infected cow's milk has been proved by numerous experiments. Gerlach fed two calves, two pigs, two rabbits, and one sheep for three weeks, on the unboiled milk from a tuberculous cow; all became infected with tuberculosis. Klebs infected nine guinea pigs in a similar manner and also a St. Bernard dog, which accidentally obtained some of the milk set aside for the guinea-pigs. Böllinger

fed four pigs, three weeks old, for ten weeks, on the milk of a highly tuberculous cow; the lymphatic glands of the neck became enlarged, and general tuberculosis was found at the end of four or five months. Another young pig was fed on the same milk for two weeks and, when killed at the end of another three weeks, showed considerable dissemination of tubercle. Of six pigs, two fed on unboiled milk became tuberculous, one of two fed on the same milk boiled was unaffected and the other became tuberculous in a few months, two fed on ordinary diet were unaffected.

Many observers (Böllinger, Sidney Martin, Crookshank, De Jong, Arloing, Ravenal, &c.) have succeeded in showing that the human tubercle bacillus will produce tuberculosis in cattle, chiefly by experiments on calves, although it has not the same degree of virulence as the bovine bacillus. The latter appears to be more virulent to all animals used for experimental inoculation. Possibly Koch's negative results were due to using too small doses of insufficient virulence. It is also urged as an argument against Koch's views that tuberculosis can be produced by feeding experiments without any evidence of a primary lesion, *e.g.*, the cervical glands of the pig (Böllinger, Woodhead), and the mesenteric glands of the guinea-pig (Cornil and Babes, Klebs, Baumgarten).

Bang found that nine out of sixty-three cows affected with general tuberculosis, but having no nodules in the udder, yielded milk containing the tubercle bacillus. Ernst found this bacillus in the milk in a much larger proportion of cows having general tuberculosis but no evident involvement of

the udder. By a very thorough examination of stained specimens of the milk of thirty-six cows, he found the bacilli in twelve. It is quite possible that undetected tuberculous deposits in the udder may have existed in some of these cows.

Hirschberger and Böllinger inoculated guinea-pigs, intra-peritoneally, with milk from the udders of tuberculous cows removed after death. In three out of nine cases, in which the cows suffered from tuberculosis of the lungs only, the guinea-pigs became tuberculous.

Sims Woodhead and Sidney Martin, as the result of their experiments, stated in evidence before the Royal Commission appointed to inquire into the Effect of Food derived from Tuberculous Animals, 1895, that:

1. The milk of tuberculous cows is *only* infective when it comes from a tuberculous udder.

2. The udder affection may occur in slight cases of tuberculosis; it is not peculiar to the advanced stages.

3. Even if only one quarter is infected the milk is very virulent.

4. Butter-milk, skimmed milk, and butter from a cow with a tuberculous udder, are actively infectious.

5. The udder affection may develop with extreme rapidity.

6. Boiling is essential for the destruction of the bacillus.

Sidney Martin experimented with the milk of eight cows in various stages of tuberculous disease, which were shown to be free from udder disease *post mortem*. Tubercle bacilli were not found in the milk of any one of these cows. Of twenty-eight

guinea-pigs and rabbits inoculated with the milk, none developed tuberculosis. Guinea-pigs fed freely on the milk remained healthy. Pigs fed on large quantities, as much as fifty-six litres from a cow in an advanced stage of the disease being given in one case, were unaffected. On the other hand, twenty-one animals inoculated with the milk of cows with tuberculous udders, all became tuberculous. In three cases the bacilli were found in the milk, and animals fed on it became tuberculous. The disease produced in every case was a rapid form of tuberculosis. The virulence of the infected milk was not diminished by dilution with four times its bulk of sound milk.

Sims Woodhead investigated the effect of heat on tuberculous milk. He used in the research milk from cows with tuberculous udders and milk rendered artificially tuberculous by the addition of tuberculous sputum or finely divided tuberculous organs. The natural tuberculous milk in its uncooked state was the most uniformly infective. The milk was kept in a specially contrived water-bath for different periods of time at temperatures ranging from 50° C. to 90° C., and was subsequently tested by feeding and inoculating experiments on animals. The following results were obtained :

(1) Partial heating rendered the milk less virulent ; only a small proportion of the test animals being affected with tuberculosis.

(2) The higher the temperature or the longer the exposure to it, the smaller was the proportion of the test animals infected with the disease.

(3) The test animals attacked under these conditions suffered from a modified form of tuberculosis,

limited and slowly progressive. The higher the temperature and the longer the exposure, short of complete destruction of the bacilli, the more limited and more slowly progressive was the disease. The animals used were guinea-pigs and were inoculated intra-peritoneally.

Milk heated for twenty-two minutes to 75° C., or for half an hour at 70° C., was capable of infecting the animals when inoculated intra-peritoneally. In feeding experiments on pigs, using artificial tuberculous material heated to different temperatures for different periods of time, Dr. Woodhead found that artificial tuberculous milk kept at 80° C. for ten minutes, or at 75° C. for a quarter of an hour, still remained infective when given as food to pigs.

It is possible that milk raised to a higher temperature for a longer period than in these experiments may still retain its infectivity to pigs.

The practical value of these results is very great. The modified form of tuberculosis produced in the pigs, by feeding them on imperfectly cooked milk, is closely analogous to the form in which the disease appears so commonly in children, namely, chronic tuberculous affections of the glands and joints.

Possibly we have two kinds of tuberculous infection in man. Some chronic forms of tuberculosis in children resemble in their effects, more especially on the spleen, the tuberculosis of guinea-pigs due to inoculation with the bovine bacillus. On the whole we must take a guarded view at present. The human tubercle bacillus is very widely distributed, and probably most cases of tuberculosis in children are due to infection through the respiratory tract. The alimentary tract is insusceptible to

infection by either kind of bacillus. Hence the risk of infection from tuberculous milk is a comparatively slight one, but at present we are not justified in regarding it as a wholly negligible quantity.

Clinical evidence is slight. Instances in support of the infectivity of tuberculous milk have been brought forward by Brouardel, Demme, Woodhead, and others. Local infection, in the form of *post-mortem* warts, is not uncommon, and might be urged in favour of human susceptibility to the bovine bacillus.

Certainly all milk from a cow with tuberculous disease of the udder must be destroyed, and dairy cows should be inspected weekly by a competent veterinary surgeon, in order to secure the immediate segregation of the affected cow. The local affection takes the form of a slow painless growth, taking weeks or months to involve a large portion of the udder. It may occur at any stage of the general disease or may remain absent throughout. The bacilli cannot always be found on microscopical examination, even with the aid of the centrifugal machine, and the only reliable test is the inoculation of animals with the suspected milk. In view of the practical difficulties in the way of deciding whether the udder disease is tuberculous or not, it is advisable to destroy the milk of any cow with any suspicious affection of that part. It is also safer not to use the milk of a tuberculous cow, even when no udder disease can be found. The use of tuberculin is a valuable means of detecting latent or active tuberculous disease.

Until some system is devised which will ensure

the milk supply being free from tubercle bacilli and other infective organisms we are compelled to counteract the danger by sterilisation.

The Methods of Sterilisation.—All the methods that are employed with safety and without introducing chemical compounds, which may or may not be deleterious, consist in the application of heat in various ways. There are three chief processes:

(1) Pasteurisation.
(2) Boiling.
(3) Sterilisation.

In each the milk is heated up to a certain temperature for a definite time. In recommending any one of these processes to the mother or nurse it is advisable to explain the reasons shortly, thus:

1. All milk contains micro-organisms in large numbers and these give rise to changes in the milk, such as souring and curdling, rendering it unfit for the child, and liable, if used, to set up violent or even fatal diarrhœa and vomiting.

2. Many harmful changes may take place in milk and render it dangerous as a food, although there may be no change apparent to the sight, smell, or taste.

3. The object of sterilisation is to destroy all the micro-organisms present in the milk and, by excluding air and keeping the milk cool, to prevent the entrance of other microbes and to hinder the development of the spores of organisms which have escaped destruction in the process.

4. If the process is properly carried out, the risk

of the child catching any infectious disease or developing intestinal affections is largely diminished.

It is important that the process adopted should be carried out as soon as possible after the milk is received, in order to stop the continued rapid multiplication of the organisms already present in the milk. If the process is postponed the products of the micro-organisms may increase to such an extent that the milk is rendered injurious. These products may not be in the least affected by sterilisation. It is essential, therefore, to have a supply of good milk to start with and to remember that no amount of sterilisation will convert bad into good milk.

A large amount of so-called sterile milk is by no means sterile and will yield colonies of micro-organisms in various culture media. Some milk, sold as sterile, is preserved by the addition of chemicals. I know of one case where a farmer's wife boils all the superfluous milk, adds some salicylic acid, and sells it as pure sterilised milk.

Pasteurisation of Milk.—In this process the milk is heated to 70° C. (158° F.) and subsequently cooled rapidly. The milk ought to be kept at this temperature for twenty to thirty minutes.

Pasteur found that a temperature of 55° C. (131° F.) prevents milk or wine turning sour. Klein, Koch and others have shown that a temperature of 70° C. (158° F.) for five minutes destroys all non-spore-bearing organisms. Some of the spore-bearing organisms, or their spores, escape destruction at a higher temperature. For instance, the spores of the bacillus subtilis resist a temperature of 100° C. (212° F.) for six hours and one of 75° C. (167° F.) for several days. A temperature of 75° C. for

twenty minutes will destroy all ordinary pyogenic germs, the colon bacillus, and the bacilli of diphtheria, typhoid fever, and tuberculosis.

The death-point of the tubercle bacillus is open to discussion. It is said to be killed:

1. By 10 minutes' exposure to a temperature of 75° C. (167° F.)
2. By 15 " " " 70° C. (158° F.)
3. By 30 " " " 68° C. (154° F.)

Schill and Fischer in 1884 found that five minutes' exposure to 100° C. in steam destroyed the bacilli in tuberculous sputum. After an exposure of two minutes one only out of three guinea-pigs, inoculated with the material, became tuberculous. It is worth mention that sputum is tenacious and in thick masses not readily penetrated by heat.

Voelsh reports, as the result of his experiments, that the tubercle bacillus in sputum was not destroyed by heating to 100° C.

Sternberg inoculated guinea-pigs with tuberculous sputum kept at various temperatures, from 50° C. upwards, for periods of ten minutes. The sputum exposed at 50° C. was infective, that exposed at higher temperatures was harmless.

Yersin in 1888 made subcultures from an old culture of the tubercle bacillus in glycerin broth after it had been exposed to various temperatures. After an exposure of ten minutes at 60° C. a growth was obtained, but none resulted after an exposure of similar duration at 70° C.

Bitter in 1890 stated that he had found by experimental inoculation of guinea-pigs that the

bacillus is destroyed by exposure for twenty minutes at 68·5° C., or for fifteen minutes at 75° C.

Forster published in 1892 the results of a considerable number of experiments. He inoculated guinea-pigs with tuberculous sputum, tuberculous material from the pleura, and the milky material squeezed out of the tuberculous tissue in the udder of affected cows. The material was found on examination to contain the characteristic bacilli. He ascertained that the bacilli were destroyed by exposure for six hours at 55° C., or for one hour at 60° C. An exposure for three-quarters of an hour at 60° C. was not sufficient to kill them.

In the same year Bonhoff published results showing that a temperature of 60° C. for twenty minutes is sufficient to kill tubercle bacilli in pure culture, or, at any rate, to render them harmless to guinea-pigs. C. de Man carried out a series of experiments in Forster's laboratory in 1893 and found that the bacillus was destroyed by exposure:

At	55° C.	for	4	hours.
,,	60° C.	,,	1	hour.
,,	65° C.	,,	15	minutes.
,,	70° C.	,,	10	,,
,,	80° C.	,,	5	,,
,,	90° C.	,,	2	,,
,,	95° C.	,,	1	,,

Schroeder inoculated milk with a culture of the bacillus and exposed it to a temperature of 60° C. for fifteen minutes. A guinea-pig inoculated with this milk was killed in eight weeks and showed no evidence of tuberculosis. Two guinea-pigs inoculated with the same milk, unheated, died from tuberculosis in three to four weeks.

Woodhead's experiments do not support the above statements as to the effect of heat on the tubercle bacillus. He found that infected milk, heated for twenty-two minutes at 75° C., or heated for thirty minutes at 70° C., was capable of producing tuberculosis in guinea-pigs, when inoculated intra-peritoneally. Similarly milk rendered artificially tuberculous by the addition of tuberculous sputum, or pounded-up tuberculous organs, remained still infective, when given as food to pigs, although previously heated for ten minutes at 80° C., or for fifteen minutes at 75° C. These experiments are of very great value as indicating that the ordinary processes of Pasteurising milk are not sufficient to render virulent tuberculous milk perfectly innocuous, although its infectivity may be largely diminished. No doubt such a fluid as milk is not as readily rendered harmless, when containing the tubercle bacilli, as the growth in culture media. Not only are the organisms much more virulent, but also the nature of the fluid makes it probable that they may escape destruction.

For all practical purposes I consider that Pasteurisation at 70° C. to 75° C. for half an hour, with subsequent rapid cooling, will render the milk from a herd of selected cows absolutely safe for infants as well as adults. I do not hold that similar treatment will destroy all the bacilli in the milk of an animal with tuberculous disease of the udder, though probably it will have such an effect on them as to render the milk harmless for food. Such milk should never be given to infants and ought to be destroyed.

The process can be carried out at the dairy with a proper sterilising apparatus, the milk being put in

suitable bottles closed by an air-tight stopper or clean new cork.

It may be carried out at home by placing the milk in a suitable receptacle, and immersing it in a suitable proportion of boiling water, leaving it in for an hour. The amount of water will depend on the nature of the vessel containing the milk, the amount of the milk, and the external temperature. With a little experience and the use of a thermometer the proportions can be soon ascertained. When the process is ended the milk should be removed from the hot water, rapidly cooled, and kept in a cool cellar or in a refrigerator. The feeds for the infant may be prepared for a period of twelve hours, put in suitable bottles in a wire framework, stoppered with clean baked cotton wool, and all Pasteurised together. The bottles can then be removed in their supporting framework to the refrigerator or cellar, until required.

The chief advantages of Pasteurisation are, that chemically the milk is not seriously changed, the taste and smell are unaltered, the microbes present are destroyed, fermentation is stopped, and the risk of the transmission of infectious disease is abolished. The milk will keep for several days in the refrigerator, but unless so kept or much cooled down, the undestroyed spores are liable to develop and cause fermentation. Spore-forming organisms may by their action on the milk produce toxic peptones or albumoses which, when given to the infant, may set up fatal diarrhœa. It must not be kept more than thirty-six hours; it is not advisable to keep it more than twenty-four hours; it is even safer not to keep it more than twelve hours, and to prepare a fresh supply twice a day. It is said to be more digestible than raw milk.

Useful apparatus for carrying out this process is described under the heading of "Sterilisation by Steam." The first two forms of apparatus supplied by Hawksley (Figs. 3 and 4) effect the result satisfactorily. Freeman recommends the Pasteurisation of milk by putting it in suitable receptacles in a definite amount of boiling water, the source of heat having been removed. The apparatus consists of a simple pail with a groove round it, to indicate the level to which it is to be filled with water, and a cover. Inside this is placed a receptacle for the bottles of milk, consisting of a series of hollow zinc cylinders fastened together; it fits into the pail in such a way that only the lower inch of the cylinders is immersed in water. For use the pail is filled with water to the level indicated by the groove, covered and put on the stove or fire. The bottles of milk are filled, stoppered with cotton wool, and placed in the cylinders. Sufficient water is placed in each cylinder to surround the body of the bottle. As soon as the water in the pail boils thoroughly, the pail is removed from the fire to a wooden table or other non-conducting surface out of a draught. The receptacle containing the bottles of milk is quickly inserted, and the cover replaced. At the end of three-quarters of an hour the cover is removed, and the pail put under a cold-water tap so arranged that the water does not run into the cylinders. In a quarter of an hour the milk is reduced to the same temperature as the water, and the bottles may be removed to a refrigerator until required for use. By this process the temperature of the milk is not raised above 70° C., and Freeman maintains that this degree of heat and length of exposure are

sufficient to destroy all injurious organisms, including the tubercle bacillus. The rapid cooling is considered an important part of the method. Very little chemical change is induced in the milk by this amount of heat.

Boiling.—The simplest method is to place the milk in a clean saucepan with a lid, and boil over a spirit or gas lamp. A better plan consists in using a special milk saucepan of porcelain, contained in the ordinary saucepan in which the water is placed. In this method there is less risk of over-heating and burning the milk, and the porcelain vessel is much more easily kept scientifically clean than the common saucepan. The boiling-point of milk is between 0·5° C. and 1·0° C. higher than that of water. The whole of the milk-supply should be boiled in this way as soon as received, and then kept in a refrigerator covered up. Boiled milk exposed to air undergoes fermentative changes almost as rapidly as if unboiled. If it cannot be rapidly cooled down, sealed up and kept in a refrigerator, it should be again boiled before being given to the infant. A very good plan is to place each feed, mixed in the requisite proportions, in a clean soda-water bottle and plug with clean cotton wool, previously well baked in the oven. Several of these can be prepared at once, and placed in a suitable support, made after the principle of the ordinary soda-water bottle-stand, and placed in a large saucepan containing water up to a level with the necks of the bottles. Saturated salt solution is sometimes recommended, instead of water, on account of its higher boiling-point. The whole can then be placed on the fire and boiled for half an hour. Before removing the bottles the

water must be allowed to cool, otherwise if they are taken out and placed at once in a refrigerator or in cold water most of them will break. Ordinary corks may be used instead of the cotton-wool plugs, provided they are well boiled for half an hour first. They are not as satisfactory for they do not allow for the expansion of the milk on heating.

A simpler apparatus still can be devised, such as a wire supporting frame-work or a board pierced with holes sufficiently large to admit the bottles; this must rest on blocks of sufficient height to keep the bottles from touching the bottom of the pan. Such an apparatus is within the reach of all, but the extra trouble involved prevents its adoption by the lower classes.

In all these methods it is probable that the milk is never actually brought to the boiling-point. When milk is boiled in the usual manner it is generally removed from the fire as soon as it begins to rise in the pan or it may boil over. This is often spoken of as "scalding" the milk. At this period of the process the temperature is about 190° F. If the froth which forms on the surface at this time, be broken up by stirring, the temperature may be raised to 214° F. The reason of this is that the milk boils first at the sides of the pan, and long before the boiling-point has been reached in the more central portions. Stirring mixes the milk and keeps it at a temperature below that at which ebullition takes place. At 214° F. milk boils with ebullition like water. Milk heated in a water bath, even for as long as forty minutes, seldom or never reaches the temperature of the boiling water unless the vessels in which the milk is contained are quite

small. Merely bringing the milk to the temperature of boiling water for a few minutes, provided the heat is distributed throughout the fluid, will destroy all known pathogenic organisms, and the temperature reached in the ordinary methods of boiling is almost equally efficacious. The rapid boiling of milk, as by heating it in a test-tube over a spirit flame or Bunsen burner, will not sterilise it on account of ebullition resulting long before the whole of the milk is raised to a sufficient temperature. Neither process ensures complete sterilisation, and as a matter of practice this is unnecessary, except in cases where milk has to be prepared for a lengthened period, *e.g.*, for a long voyage.

The objections to boiling are:

1. It alters the taste and smell of the milk

2. It coagulates the lact-albumin. As the milk cools a thick tenacious scum forms on the surface. This is composed of coagulated albumin, fat, and an excess of phosphates, and does not disappear on shaking.

3. It devitalises the milk; children fed entirely on boiled milk are somewhat liable to scurvy.

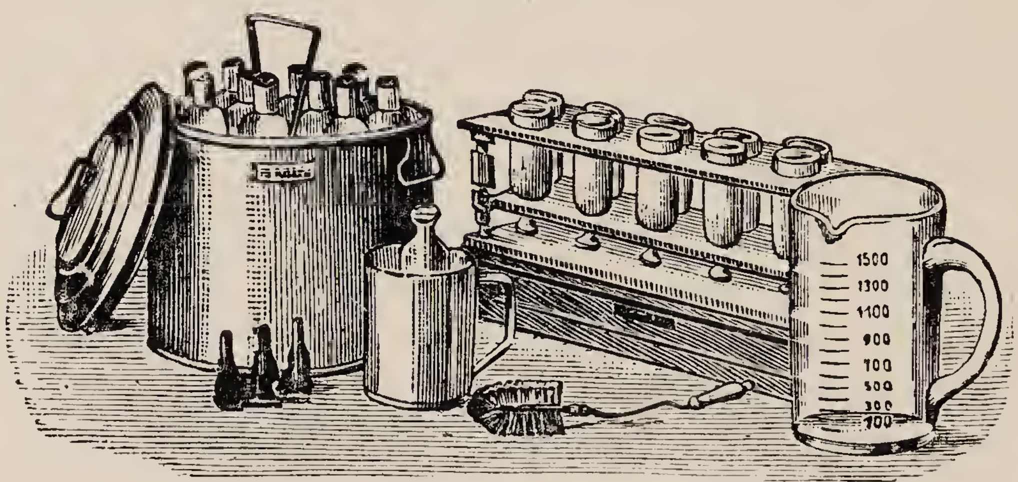
4. It renders the milk more indigestible than in its raw state and less nutritious. This is denied by some authorities and will be considered later.

Boiled milk on cooling, and the addition of rennet, is said not to form a large coherent clot like fresh milk but yields a flocculent precipitate of casein. My own observations do not confirm this (*vide* chap. xiii.). The digestibility of the fat is said to be unaltered (*vide infra*). The great advantage of this process is its simplicity. If a

proper milk saucepan is used and the boiling is not carried out too rapidly, very good results are obtained.

Sterilisation by Steaming.—In this process the milk is subjected to the influence of superheated steam for twenty to thirty minutes. The

FIG. 2.



Soxhlet's Apparatus for Sterilisation.

results are almost the same as when the milk is boiled, but certain advantages are claimed for it.

A great number of different sterilisers are in the market, a few of which are here described as illustrative of the methods. Apparatus for sterilising milk on a large scale can be now easily obtained and is used in an increasing number of dairies.

A moderately cheap one, and one of the best for home use, is *Soxhlet's*, consisting of the following articles:

1. Twenty well-annealed 5-oz. bottles with stoppers of rubber and glass combined. Each rubber stopper fits well into the neck of the bottle and is perforated in order to admit a slender glass stopper.

2. A wooden stand with zinc dripping-pan for inverted reserve bottles and a drawer for extra corks, tips, &c.

3. A graduated glass beaker with a handle for mixing the milk, water, and cream in the proportions required.

4. A tin or galvanised zinc tray for ten bottles fitting into a tin pot with a suitable cover to contain the water.

5. A water-bath in the shape of a tin mug with a double bottom, the inner one perforated, for warming each bottle of sterilised milk before use.

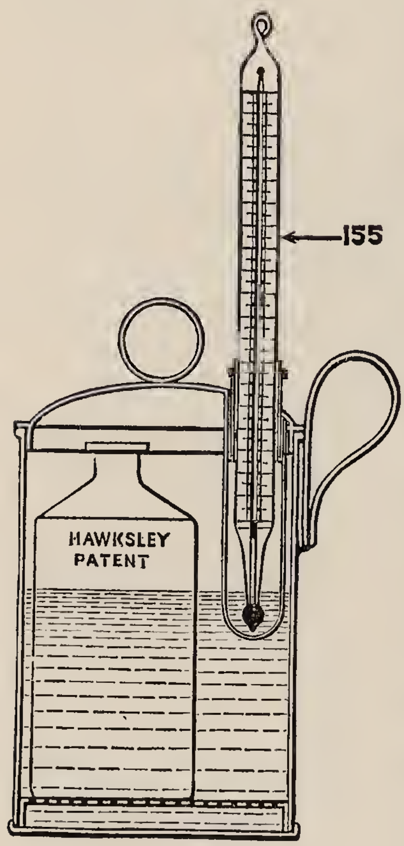
6. A proper supply of rubber tips and some bristle brushes for cleaning the bottles, &c.

Mode of Preparation.—Ten bottles are filled with milk to within half an inch of the neck and a perforated rubber stopper is pressed into each. The bottles are placed in the tray and set in the pot of water, the cover replaced and the whole put on the fire. As soon as the water has come to a boil and expansion of the milk has taken place the glass stoppers are pressed into the rubber ones and each bottle is thus hermetically sealed. Boiling is then continued for fifteen to thirty minutes, and after that the whole is removed from the fire and allowed to cool. Milk treated in this way will keep sweet for from four to six weeks. When the milk is required for use the bottle is put in the warming tin, containing hot water, until it is warm. The stopper is then removed and an ordinary rubber tip attached.

Rotch's Apparatus is a good deal simpler. It consists of a tin pail eight or nine inches in diameter and eighteen or nineteen inches high, raised on three legs sufficiently high to allow a

Bunsen burner to stand underneath. A stand like a cruet-stand holds the feeding-bottles. The cover of the pail has a small hole in it to allow the escape of steam and is fitted with a thermometer. The feeding-bottles are similar in shape to a test-tube with a footpiece and are of a suitable size for each feed. The requisite amount of food for a feed is placed in each. The bottles are stoppered with non-absorbent cotton wool and are placed in the stand inside the pail. Water is poured in to the level of the top of the milk in the bottles. The lid is put on, the gas lighted, and the whole steamed for twenty minutes. The bottles are then removed and allowed to cool. Before the bottle is given it is immersed in hot water in a tin mug until warm, and after it is warm the cotton wool is removed and a teat put on. Food prepared in this way will keep for a long time and is extremely useful while travelling. Rubber cots put over the mouths of the bottles can be used instead of cotton wool. They are useful while travelling, and also prevent the entrance of air during the cooling process.

FIG. 3.



Hawksley provides three kinds of apparatus:

No. 1 (Fig. 3) consists of a saucepan with a wire handle, a lid, and an attached thermometer which dips, when in use, into the water in the saucepan. The milk is placed in a bottle which rests on a wire

framework, two inches from the bottom of the saucepan, and is stoppered with a plug of cotton wool. The water in the saucepan should be cold and reach to about the level of the milk in the bottle. The cover is put on and the apparatus heated on a gas stove or fire until the thermometer indicates a

FIG. 4.

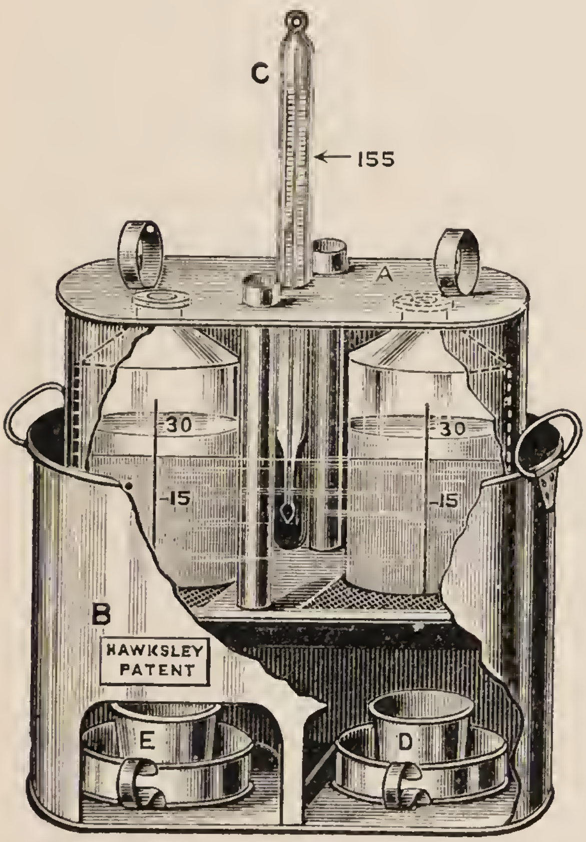
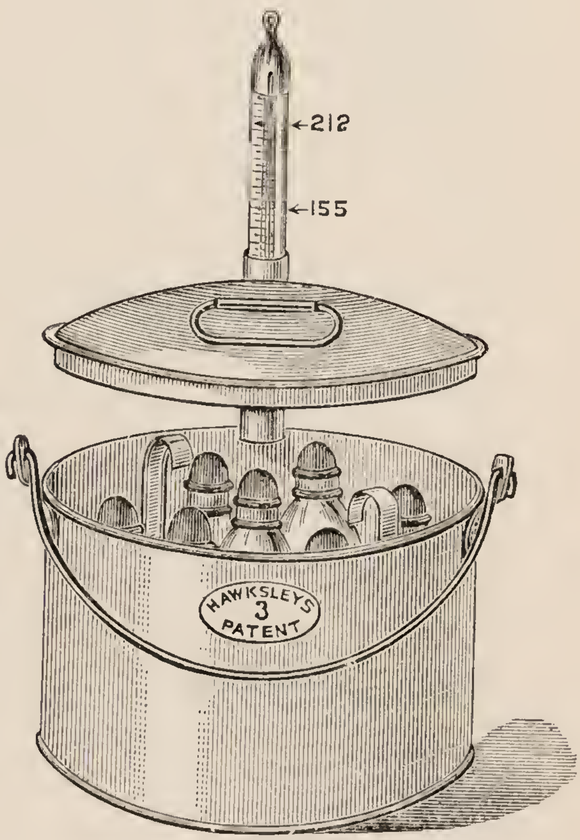


FIG. 5.



temperature of 155° F. It is then removed and allowed to stand for half an hour, after which it is rapidly cooled and kept in a cool place. This method is a form of Pasteurisation.

No. 2 (Fig. 4) is a double apparatus, oval in shape, consisting of a jacket and boiler. The boiler A is removable and is contained in the upper part of the jacket B. In the lower part are recesses for two spirit lamps D and E. Passing through the lid of the boiler is a thermometer C. Gas burners may be

used instead of the spirit lamps, or the boiler may be removed entirely and heated on an ordinary fire or a gas stove. When using this apparatus the milk is put in the bottles, which are then plugged with cotton wool and placed in the boiler. Water is poured into the boiler almost up to the level of the milk. The lid and thermometer are replaced and the whole heated, either in the jacket or otherwise, until the temperature 155° F. is reached. Then remove the boiler, take off the lid, and at once re-plug the mouths of the bottles with clean sterile cotton wool. Leave in the hot water for half an hour and then cool quickly and store in a cool place. This method, like No. 2, is a form of Pasteurisation.

No. 5 is a modification of the apparatus used by Budin of Paris. It consists of a boiling-pan fitted with a movable tray of seven cells, a lid and attached thermometer. The seven cells receive seven bottles furnished with red rubber valved caps; each bottle is to hold enough food for one meal. The other appliances necessary are a food warmer, such as has been previously described in Soxhlet's apparatus; a few soft reversible rubber teats or nipples, and bristle brushes for cleaning the bottles. When using this apparatus the milk mixture is put in the bottles and must not reach a higher level than the shoulder; a red rubber cap is put on each, and cold or warm water poured into the boiling-pan up to the level of the milk. The lid and thermometer are replaced and the whole put on the fire or gas stove until the temperature 212° F. is reached; it must be then kept at this temperature for forty minutes. After this remove the boiler from the fire, take out the tray and bottles and put aside in a cool place

until required. When wanted take out a bottle, warm in the food-warmer up to 100° F., take off the cap and put on a soft rubber teat and give at once.

Food-Warmer.—The best kind is one such as previously described (p. 237) but having in addition a small hole near the handle through which the thermometer can pass into the water. The water should be cold or lukewarm at first and heated slowly by putting it over a gas or spirit flame, on the hob, or in a larger vessel containing boiling water. If the heat is applied too rapidly the temperature of the water reaches 100° F. long before the milk in the more central portion is sufficiently warmed.

FIG. 6.

The Bottles.—A plain flint glass, rather wide-mouthed, bottle is the most suitable for use in the above apparatus. It is useful to have the bottles graduated on the outside. Such bottles can be easily kept clean and make excellent feeders. The tips are composed of soft rubber and have a small opening in the form of a cross cut at the end; this shaped opening obviating the necessity of a second opening for the admission of air. After being thoroughly scrubbed with the bristle brush and hot soda and water, and rinsed out in pure hot water several times, the bottles should be kept in an inverted position until required (*vide* Fig. 6).

Warner's Apparatus consists of an ordinary cooking steamer filled to a height of two inches with

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water which is brought to a boil. Place the milk, mixed as required, in as many feeding-bottles as are needed for the number of feeds to be given in the twenty-four hours. These bottles, having been thoroughly cleaned and put in an oven for fifteen minutes before being filled, are stoppered with pledgets of well-baked cotton wool and placed on the perforated plate of the steamer but not touching each other, the cover shut tightly down, the steamer placed on the fire and the whole allowed to steam for thirty minutes. When cool, the bottles may be kept in a refrigerator or in a cool cellar. Each must be warmed before use. It is advisable to use rubber cots such as Rotch recommends, in order to prevent air being drawn in during the cooling process. A rubber tip should be put on just before use. Milk prepared in this way will remain sweet for four to five weeks.

Other apparatus can be obtained, such as Escherich's (*vide Lancet*, February 1891, and *Sajous' Annual*, vol. ii. 1892), Louis Starr's (*Sajous' Annual*, 1891), Caillé's, Seibert's, &c.

Any one of these methods may fail through the bottles not being kept clean or on account of the milk having undergone deleterious change before sterilisation. Many bottles, supposed to be clean, show on the inner surface a slight white cloudiness: such bottles should be re-cleaned. As soon as a bottle has been used it must be rinsed out under the tap and left full of cold water. Later it must be washed with a bristle brush and a free supply of soft soap or soda and hot water. Rinse out several times in cold water, wipe the outside dry and place neck downwards in a bottle-holder. Bottles should

be made of clear flint glass so that any speck of dirt may be visible. If graduated in tablespoons, ounces or cubic centimetres the marking must be on the outside.

The importance of these methods of preserving milk is well shown by the following observations.

Milk boiled and placed in a refrigerator in an open vessel turns sour in from 12-48 hours. If boiled and, after cooling, poured into small bottles stoppered with rubber or cork stoppers, it turns sour in about four days. If boiled for fifteen minutes in small bottles, the bottles being closed with plugs of cotton wool, or rubber or cork stoppers, before removal from the boiling water, the milk will remain good for five days or more. If boiled in the usual manner and left standing in an open vessel in a room at a temperature about 75° F. it will have a sour taste and smell in 12–24 hours.

From the above considerations it is clear that sterilisation is necessary in order to preserve milk for any length of time and in order to render it absolutely non-injurious. Such sterilisation can be carried out in any well-regulated household without much trouble or expense. Boiling for 20–30 minutes in small bottles stoppered with plugs of previously baked cotton wool is all that is required. At present it is possible to buy sterilised milk in town, and in two respects the supply has a distinct advantage over the home sterilised milk. It is first passed through a centrifugal separator and by this means a large amount of dirt and foreign bodies is removed, and the process is begun as soon as the milk is received, and therefore before the

number of developed micro-organisms is as great as in the milk when it reaches the individual. It is consequently more easily and completely sterilised and there is less risk of previous deleterious changes in the milk rendering it injurious although sterilised. Home methods are safer than commercial ones, for the latter may lead to the preservation of unsound milk or to the permanent separation of the fat. Hay bacilli are sometimes found in commercial milk, causing decomposition of proteid and the evolution of sulphuretted hydrogen. This has happened in my experience even in milk from the best regulated milk laboratories.

Objections to the Use of Sterilised Milk.—For several reasons the use of such milk has not come up to expectations. It is said to be less digestible than fresh milk, owing to it not being curdled in the stomach. It is liable to give rise to modified or even severe forms of scurvy, some anti-scorbutic property being destroyed by heat. Many cases of scurvy have been reported in infants fed on sterilised milk. Cases have come under my notice in infants fed upon milk sterilised at home, on Pasteurised milk, on commercial sterilised milk, and on various condensed milks and patent foods. The disease is of slow development. In one instance the baby, aged thirteen months, had been taking Pasteurised milk for ten months. In an infant fed on milk sterilised at home symptoms appeared in five months. Recovery usually takes place rapidly on uncooked milk, raw meat juice, and fruit juice. Sterilised milk fails to prevent diarrhœa, and in many cases to stop diarrhœa when present. Rotch claims for steamed milk certain advantages:

1. The odour and taste of boiled milk are present, but to a much less extent.

2. The scum formed by the coagulated albumin is thin and not tenacious and almost entirely disappears on shaking.

Raw, steamed and boiled milk coagulate to the same extent on the addition of acetic acid. The size of the curd produced depends entirely on the degree of dilution. Even if obtained direct from the udder the curd formed is as large as when the milk is twenty-four hours old.

The effect of rennet on the various modifications of milk will be considered subsequently. At present it need only be stated that the coagulability to rennet is considerably modified by the different modes of preparation.

The Effects of Heat upon Milk.—In considering the effects of heat on milk we have to estimate the importance of two questions. Is the danger of uncooked milk, from the point of view of infection, a substantial one? And is the nutritive value of the milk seriously impaired by the heat to which it is exposed? So far the only advantage that can be claimed is that the micro-organisms present are destroyed. Complete sterilisation, including the destruction of all spores, requires a high temperature and considerable length of exposure. Flügge denies that sterilisation for three-quarters of an hour or longer destroys all spores. He found that from milk kept for some time at 90°–95° C. various anaërobic bacilli could be subsequently cultivated at 30° C. The *bacillus butyricus* of Botkin was the most common, and rendered the milk toxic to guinea-pigs. He enumerates twelve varieties of

spores of aërobic bacilli which survived in milk kept at boiling-point for two hours; they produce peptones and thus indirectly give rise to diarrhœa. Rodet found that milk was only rendered sterile by exposure to a temperature of 110°–120° C., an expensive plant being necessary, and the colour and taste altered.

To ensure absolute sterilisation Soxhlet's apparatus should be used and the milk subjected to the process for two periods of a quarter of an hour on successive days. This is only necessary when a large quantity of milk is wanted for travelling.

It has been already shown that the ordinary infective organisms are destroyed by heat. So too is the streptococcus pyogenes, an organism proved by numerous observers to be definitely connected with the severe gastro-enteric infections of infancy. Pus, muco-pus, and blood may be found in milk, due to inflammatory disease of the udder. G. L. Eastes (*British Medical Journal* 1899) examined 186 specimens of milk and found the tubercle bacillus in 11, pus in 47, muco-pus in 77, and streptococci in 106. It is abundantly clear, therefore, that the danger in uncooked milk from the point of view of infection is a substantial one.

The chemical changes which take place in the milk between 75° C. and 100° C. (167°–212° F.) render the milk unsatisfactory for the purposes of perfect nutrition and these changes become more marked the higher the temperature and the longer the exposure to it. The change begins at 60° C. (140° F.). Some observers have gone so far as to maintain that the sole use of sterilised milk gives rise to slow starvation. It is hardly necessary to

add that this is an exaggeration. I have found many infants increase steadily in weight and strength on a diet of sterile milk.

There is one quality which is destroyed by heat, namely, the anti-scorbutic quality. It is at its highest when the milk leaves the udder. It diminishes with the age of the milk. It deteriorates on being exposed to heat. The higher the temperature to which the milk is exposed the more complete is the destruction of this property. This property is probably connected with the citric acid present in milk. Heat precipitates it in the form of an insoluble citrate of calcium. Heat also is said to destroy nuclein and lecithin, to dehydrate sugar, and to convert phosphorus in organic combination into inorganic phosphate.

Leeds and Davis have come to the five following conclusions:

1. "Raising the milk to 100° C., and retaining it at that temperature, converts a considerable part of soluble into insoluble proteid." This is certainly true of the lact-albumin; the longer the milk is boiled the more insoluble does this proteid become.

2. "The casein of boiled milk is less readily coagulated by rennet and yields slowly and imperfectly to the action of pepsin and pancreatin."

Koplik also asserts that the casein loses its coagulability to rennet, and that amounts of rennet sufficient to act on raw milk have no effect on milk previously heated to 85° C. My own experiments give a similar result.

3. "The fat globules are somewhat affected, the coagulated proteid becoming attached; hence some difficulty in fat assimilation."

Renk has pointed out that in sterilised milk, when kept, the fat passes out of emulsion so that on boiling it runs together in big lumps and cannot be emulsionised again by shaking. The change begins to be rapid after keeping a week. Unsterilised milk yields more butter and more quickly.

4. "Milk sugar is completely destroyed by long continued heating and is probably affected to a certain extent by sterilisation."

5. "The galacto-zyme, a ferment present in milk in minute quantities with the power of liquefying starch, is destroyed at boiling-point."

The Assimilation of Sterilised Milk.—Vassilieff experimented on six healthy young men between the ages of eighteen and twenty-three. Each experiment lasted six days. During the first three the diet consisted of raw milk and for the next three days of boiled milk. The amount consumed varied between 1850 c.c. and 4200 c.c. daily. He arrived at the following conclusions:

(*a*) The nitrogenous ingredients of boiled milk are less readily assimilated than those of unboiled milk.

TABLE LXVIII.

Percentage of Non-assimilated Nitrogen.

	Average.	Maximum.	Minimum.
Unboiled milk	7·05	7·62	6·42
Boiled milk	8·18	8·79	7·76

(*b*) The fat is less readily assimilated when the milk is boiled.

TABLE LXIX.

Percentage of Non-assimilated Fatty Acids.

	Average.	Maximum.	Minimum.
Unboiled milk	3·89	4·85	2·88
Boiled milk	6·01	6·99	4·53

The percentage of fatty acids, in relation to the total quantity of dried fæces, is considerably larger on a diet of boiled milk than on a diet of unboiled milk; in other words the fat is less readily assimilated. Unboiled milk is therefore superior to boiled milk for the purposes of nutrition.

Raudnitz, by analysis of the milk and of the urine and fæces, also has shown that less nitrogenous material is absorbed from boiled than from unboiled milk.

Koplik experimented on infants between three and six months of age on known diets, estimating the nitrogen in the fæces. He found that under all diets the amount of nitrogen daily excreted varied between 1·7 per cent. and 3·2 per cent. The nitrogen in the urine was not estimated. A curious point to be noticed in his investigations is the small amount of total fæces evacuated.

Case I. Fed on the breast and sterilised milk. The average excretion of nitrogen in the fæces for five days was 3·2 per cent.

Case II. Fed on sterilised milk, a total amount of 2880 grammes in six days; equivalent to 339·84 grammes of dry solids yielding 14·61312 grammes of nitrogen.

Result: a loss of ·84888 grammes of nitrogen in the fæces—*i.e.*, a loss of 5·8 per cent.

Case III. A male twelve weeks old, atrophic, but without any active disturbance of digestion.

TABLE LXX.

The Assimilation of Milk.

Diet.	Amount taken.		Lost in the fæces.		
	Total Milk.	Dried Solids.	Nitrogen.	Total Nitrogen.	Percentage of total nitrogen ingested.
	c.c.	grms.	grms.	grms.	
Pasteurised Milk; 7 days	2370	303·36	10·92096	0·5114642	4·6
Sterilised Milk; 7 days	2985	382·08	13·7448	0·685835	4·9
Unboiled Milk; 3 days	1170	149·76	5·39136	0·1959448	3·4
Case IV. Male, age five months.					
Milk sterilised at 100° C.; 7 days	5550	688·2	30·969	1·14454437	4·3
Milk brought to a boil on the fire; 7 days	5850	725·4	32·643	1·49874275	4·5

These observations show that the percentage amount of nitrogen unabsorbed is practically the same whether the milk is Pasteurised, boiled, or sterilised, and that the percentage unabsorbed is much less when the milk is unboiled.

Needless to say, experiments of this nature require extreme care and patience and are open to many sources of fallacy. Bendix, experimenting on children between two and two and a half years of age, came to the conclusion that the nutritive properties of sterilised and unsterilised milk are about the same. He also found that boiled and sterilised milk are equally well assimilated. His conclusions may be right and yet not invalidate Koplik's experi-

ments for at the age to which the children he made use of had attained, the digestive functions are more powerful than in infancy. Two sources of fallacy should be remembered. If the child's digestion is impaired more nitrogen is excreted in the fæces and consequently the percentage will be higher. Again the percentage may be diminished on account of the presence of an excess of undigested fat in the stools.

Weber carried out a series of experiments in feeding young animals on milk. Six calves were fed as follows: two on skimmed milk; two on sterilised milk; two on fresh milk. The experiment lasted five weeks. At the end of that time the growth and gain in weight were about the same in all the animals, but there was a striking difference in the quantity of milk taken per diem.

TABLE LXXI.

Quantity of Milk taken.

	At the beginning.	At the end.
Skimmed milk	8 quarts	16 quarts
Sterilised "	7 "	16 "
Fresh "	4 "	13 "

In other words, the nutritional value of skimmed milk was practically equivalent to that of sterilised milk, but considerably less than that of fresh milk. This result is analogous to what we find by experience in the artificial feeding of infants; sterilised milk being less nutritious than uncooked milk.

A comparison of the rate of growth of infants brought up at the breast and those reared on sterilised milk, shows how much more valuable for the infant is the former method of feeding. Budin gives the following averages obtained by the careful

feeding and weighing of almost two hundred infants :

TABLE LXXII.

The Rate of Growth (BUDIN).

	Average increase daily.	Number affected with diarrhœa.
89 infants breast-fed after the third day	28·17 grms. ($7\frac{1}{4}$ drms.)	6
91 breast-fed, plus sterile milk, after the second day	18·16 grms. ($4\frac{5}{8}$ drms.)	7
11 fed on sterile milk only	14·24 grms. ($3\frac{5}{8}$ drms.)	0

Keilmann's results (p. 177) show that breast milk is much more nutritious than a fat milk of similar composition, but sterilised.

According to C. Chamouin, kittens fed on boiled milk were "twice again as fat" (*sic*) as those supplied with raw milk. It is also more readily digested and agrees with a higher percentage of cases than unboiled milk.

Summary.—(1) It is unsafe to use uncooked milk in towns or in the country, except under special circumstances.

(2) The taste is markedly altered by a temperature over 70° C. (158° F.).

(3) Cooked milk is not as nutritious as uncooked milk.

(4) The degree of nutritive value of cooked milk does not vary with the method of cooking, according to the observations at present at our disposal.

Probably the nutritive value diminishes in proportion to the degree of heat and the length of exposure.

(5) Pasteurisation is an efficacious process for destroying the dangerous microbes present in milk.

Sterilisation at higher temperatures is not necessary in ordinary circumstances. Neither process will destroy toxins previously formed.

(6) No method will convert bad milk into good milk. The cows should be healthy, their food and water-supply excellent, the sanitary state of the farm perfect, and the milking and subsequent management of the milk carried out on scientific principles. A clean and good milk-supply is of more importance than methods employed to counteract the defects in an imperfect milk. These methods are, however, necessary in the present state of our civilisation.

CHAPTER XIII.

THE EFFECTS OF HEAT AND ATTENUANTS ON THE CURDLING OF MILK.

Comparatively few observations are recorded on this branch of the subject. Two statements are frequently made in the various works on the feeding of infants. In the first place it is asserted that attenuants, such as barley water or lime water, diminish the curdling properties of milk. In the second place it is stated that exposure of milk to high degrees of temperature for a short time, or to a lower heat for a more prolonged period, renders it uncoagulable on the addition of rennet.

To satisfy myself on these two points the following series of experiments were carried out. The milk used was bought in the shop of a London dairy company, and was of good average quality. It was exposed to heat in test-tubes, containing measured quantities, placed in a water-bath or autoclave. The latter is a strong metal apparatus in which the milk is exposed to superheated steam under considerable pressure.

After being heated the coagulability was tested by the addition of five drops of dilute acetic acid, P.B. preparation, to each portion of milk in the test-

tubes; each tube being previously cooled and, on adding the acid, inverted twice in order to mix it well with the milk. For testing the coagulability to rennet ferment the heated milk was reduced to a temperature of 40° C., a definite quantity of prime Bristol rennet added, and the whole kept in a water bath at 40° C. until coagulation ensued.

In each case, in order to investigate the nature and degree of fineness and coherence of the resulting curd, the contents of the test-tubes were poured out gently on to slabs of brown paper. The degree of cohesion was further tested by transferring the curd to a beaker and gently shaking it up with water.

According to these experiments (Table LXXIII.) the size of the curd produced by the action of acetic acid and the cohesion, as shown by the readiness with which the curd breaks up on shaking gently with water and the size of the flocculi thus produced, are only slightly, though definitely, influenced by the height of the temperature and the length of the exposure. From the results obtained the following conclusions may be drawn:

(*a*) The curd produced in unheated milk is larger and more coherent than that of milk heated for $\frac{1}{4}$ hour to degrees of temperature up to 110° C. At a higher temperature the curds became more coherent, the cohesion increasing with the duration of the exposure.

(*b*) By lengthening the duration of exposure at 80° C. and 100° C., finer and less coherent curds resulted on the addition of the acid. The difference in the results at these two temperatures was not very marked.

(*c*) The finest curd resulted after exposure of the milk to 110° C. for $\frac{1}{2}$ hour, or to 100° C. for one hour daily for three successive days.

TABLE LXXIII.

The Effect of Acetic Acid on Undiluted Milk at Various Temperatures.

5 c.c. of milk used in each test and 5 drops of dilute acetic acid added.

	Degree of heat.	Duration of Exposure.	Nature of Curd.
		Hour.	
1	Unheated milk	—	Curd large and coherent.
2	Milk heated in water - bath at 80° C.	$\frac{1}{4}$	Curd large, a little less coherent than 1.
3		$\frac{1}{2}$	Rather finer than 2.
4		$\frac{3}{4}$	Finer than 3.
5		1	Finer than 4.
6	Milk heated in water - bath at 100° C.	$\frac{1}{4}$	The curds closely resemble those of the corresponding series, 2–5. They break up a little more readily into fine flocculi on shaking with water. The longer the duration of exposure the slightly finer are the flocculi.
7		$\frac{1}{2}$	
8		$\frac{3}{4}$	
9		1	
10	Milk heated in autoclave at 110° C.	$\frac{1}{4}$	Curd finer than 2 and 6.
11		$\frac{1}{2}$	Fine and flocculent, much finer than 3.
12		$\frac{3}{4}$	More coherent than 11, resembles 3.
13		1	More coherent than 12, flocculent coagula, not nearly as fine as 5.
14	Milk heated in autoclave at 120° C.	$\frac{1}{4}$	The curds are all more coherent than those of the corresponding series, 10–13. The cohesion of the flocculi becomes more marked the longer the exposure at this temperature. A slight change in colour resulted.
15		$\frac{1}{2}$	
16		$\frac{3}{4}$	
17		1	
18	Milk heated to 100° C. for 1 hour daily on three successive days		The curd resembles 11 closely, but is a little less coherent.

(*d*) Exposure to 120° C. rendered the resulting curd more coherent than exposure to lower degrees of temperature. The longer the exposure the more coherent was the curd.

(*e*) The longer the exposure at 110° C., beyond ½ hour, the more coherent the curd became.

(*f*) The best results obtained (Exp. 11 and 18) were very unsatisfactory when compared with the result of adding acetic acid to human milk. The curd produced in the former was flocculent, but yet very much larger than that produced in the latter.

Conclusion.—The effect of heat alone on cow's milk will not render it similar to human milk in its reaction to acetic acid.

The series of experiments in Table LXXIV. (p. 258) was devised to estimate the action of acetic acid on diluted milk. The results may be summed up shortly thus:—

(*a*) The size of the curd produced by the action of acetic acid depends mainly on the degree of dilution of the milk.

(*b*) The effect of moderate exposure to heat is the same as in the case of undiluted milk. It renders the resulting curd a trifle finer.

(*c*) Exposure at 100° C. gives better results than exposure at 80° C.

(*d*) Exposure at 100° C. gives better results than exposure at 110° C.

(*e*) The longer the exposure at 110° C. the worse is the result.

(*f*) The best result is obtained by diluting milk with twice its bulk of water, and exposing it for ¼ hour to a temperature of 100° C.

TABLE LXXIV.

The Effect of Acetic Acid on Diluted Milk at various Temperatures.

Degree of Dilution.	Degree of Heat.	Nature of the Curd.
19. Milk, 2 parts + water, 1 part . .	unheated	Resembles 11, Table LXXIII.
20. ,, ,, . .	$\frac{1}{4}$ hour at 80° C.	Slightly finer than 19
21. ,, ,, . .	$\frac{1}{4}$,, 100° C.	Finer than 20
22. ,, ,, . .	$\frac{1}{4}$,, 110° C.	Larger and more coherent than 21
23. ,, ,, . .	$\frac{1}{2}$,, 110° C.	Larger and more coherent than 22
24. Milk, 1 part + water, 1 part . .	unheated	Finer than 19
25. ,, ,, . .	$\frac{1}{4}$ hour at 80° C.	Finer ,, 24 and 20
26. ,, ,, . .	$\frac{1}{4}$,, 100° C.	Finer ,, 24 and 27
27. ,, ,, . .	$\frac{1}{4}$,, 110° C.	Larger ,, 26
28. ,, ,, . .	$\frac{1}{2}$,, 110° C.	Larger ,, 27
29. Milk, 1 part + water, 2 parts . .	unheated	Finer than 24
30. ,, ,, . .	$\frac{1}{4}$ hour at 80° C.	Finer than 29 and 25
31. ,, ,, . .	$\frac{1}{4}$,, 100° C.	Very fine ; like human milk
32. ,, ,, . .	$\frac{1}{4}$,, 110° C.	A trifle larger than 31
33. ,, ,, . .	$\frac{1}{2}$,, 110° C.	Larger than 32

The next series of experiments was devised to estimate the effect of common diluents, added to milk, on its coagulability to acetic acid.

TABLE LXXV.

The Comparative Effect of Common Diluents on the Coagulability with Acetic Acid.

34. Milk, 2 parts +	*a.* Water, 1 part.
	b. Thin barley water, 1 part.
	c. Thick barley water, 1 part.
	d. Lime water, 1 part.
35. Milk, 1 part +	*a.* Water, 1 part.
	b. Thin barley water, 1 part.
	c. Thick barley water, 1 part.
	d. Lime water, 1 part.
36. Milk, 1 part +	*a.* Water, 2 parts.
	b. Thin barley water, 2 parts.
	c. Thick barley water, 2 parts.
	d. Lime water, 2 parts.

The comparison was made with unheated specimens, at 80° C., at 100° C., and at 120° C. Heat was applied for periods of $\frac{1}{4}$–1 hour, as in the other experiments. The same total bulk of the diluted mixtures was used in each experiment, and five drops of acid added. The results showed that on dilution with weak barley water finer curds were produced by the action of acetic acid than when plain water, thick barley water, or lime water was used as the diluent. The greater the degree of dilution, the finer was the resulting curd. The comparative results were analogous at all temperatures and with different durations of exposure. In the case of lime water, however, the results were of no value at temperatures above 80° C., on account of the change in colour produced in the milk by the action of the heat. At 80° C., and in unheated milk, lime water did not prove as satisfactory a diluent as the thin barley water. The barley water

was made by previously washing a teaspoonful of pearl barley several times in cold water. This was strained and put in a clean jug, and half a pint of boiling water poured on it. After stirring occasionally and allowing it to stand for an hour it was strained through muslin. Stronger barley water was made in a similar way, a tablespoonful being used instead of a teaspoonful.

The results of dilution with the thicker barley water were almost identical with those produced by dilution with lime water. With each of these diluents the resulting curd was a little finer than when only plain water was used. In other respects the size of the curd depended on the degree of dilution.

TABLE LXXVI.

The Effect of Rennet on Undiluted Milk, Sterilised by Exposure to 100° C. on 3 Successive Days for 1 Hour Daily.

1. Milk, 5 c.c. + 20% prime Bristol rennet kept in a water-bath at 40° C.	Coagulation began in 45 minutes. At the end of 55 minutes a soft curd was formed which broke up into fine flocculi and a few flakes on shaking with water.
2. Milk, 5 c.c. + 16% rennet	Trace of coagulation in 45 minutes. At the end of 55 minutes the results were the same as in 1.
3. Milk, 5 c.c. + 12% rennet	Coagulation began in 50 minutes. Results at the end of 55 minutes, the same as in 1.
4. Milk, 5 c.c. + 8% rennet	Coagulation began in 50 minutes; moderate in 60 minutes. The curd very soft and breaks up into finer flocculi than in 1–3.
5. Milk, 5 c.c. + 4% rennet	Rate of coagulation and results the same as in 4.
6. Milk, 5 c.c. + 1% rennet	No coagulation in 70 minutes.

This series of experiments shows that milk sterilised to this extent is rendered very much less coagulable with rennet. One drop of the rennet used coagulated fresh milk firmly in two minutes.

The action of rennet was further tested on undiluted milk heated to various degrees of temperature for periods of $\frac{1}{4}$–1 hour. The time at which curdling was produced and the nature of the resulting curd were noted. Half a cubic centimetre of prime Bristol rennet was added to 5 c.c. milk in each experiment, except 15 and 17. The heated milk was reduced to a temperature of 40° C. before the rennet was added, and was then kept at that temperature in a water-bath.

TABLE LXXVII.

The Effect of Rennet on Undiluted Milk at Various Temperatures.

	Amount of Heat applied.		Time of curdling.	Nature of the Curd.
		hrs.	mins.	
1	Fresh milk unheated	—	2	Very coherent curd.
2	Milk heated in water-bath at 80° C. for	$\frac{1}{4}$	3	A similar coherent curd was formed in all. A trifle softer in the more heated specimens.
3		$\frac{1}{2}$	3	
4		$\frac{3}{4}$	3	
5		1	3	
6	Milk heated in water-bath at 100° C. for	$\frac{1}{4}$	3	The curds corresponded with those of series 2–5 but were a trifle softer, especially 8 and 9, in which coagulation occurred more slowly.
7		$\frac{1}{2}$	3	
8		$\frac{3}{4}$	4	
9		1	5	
10	Milk heated in autoclave at 110° C. for	$\frac{1}{4}$	3	The curds were a little softer than those of series 6–9, especially 12 and 13 which curdled more slowly than the others.
11		$\frac{1}{2}$	3	
12		$\frac{3}{4}$	5	
13		1	7	
14	Milk heated in autoclave at 120° C. for	$\frac{1}{4}$	3	Curd softer than 2, 6, and 10, and breaks up rather more easily on shaking with water.
15		$\frac{1}{2}$	10	Feeble coagulation with $\frac{1}{4}$ c.c. rennet.
16		$\frac{1}{2}$	10	Better coagulation with $\frac{1}{2}$ c.c. rennet.
17		$\frac{1}{2}$	10	Good soft coagulation with 1 c.c. rennet.

This series of experiments shows that if sufficient rennet be added the nature of the resulting curd is almost the same, no matter what amount of heat is applied to the milk. A slight difference was certainly perceptible in the degree of coherence of the curds. The coherence was more marked in the less heated specimens.

More rennet is required to curdle milk that is heated, and the amount required increases with the height of the temperature to which the milk is exposed and the duration of the exposure. One drop of rennet curdled 5 c.c. of unheated milk in 2–3 minutes, whereas 1 c.c. was required to curdle milk, heated to 120° C. for half an hour, in 10 minutes. Even then the resulting curd was soft and feebly coherent.

Further experiments were carried out to test the effect of rennet on milk diluted in various proportions and heated to various temperatures. The experiments were carried out after the same method as those of the last group.

TABLE LXXVIII.

Effect of Rennet on Milk diluted with half its bulk of Water.

1. Unheated milk . . .	Curdled in 3 minutes; the curd less coherent than when the milk is undiluted.
2. Milk heated in a water bath for 1 hour at 100° C. .	Slight taste and smell of boiled milk; curdled in 3 minutes; the curd a little softer and less coherent than that of the diluted unboiled milk.
3. Milk heated in autoclave for ¼ hour at 110° C. . .	Resembles 2 in taste, smell, and curdling.
4. Milk heated in autoclave for ½ hour at 110° C. .	More marked taste and smell of boiled milk; curd produced in 3 minutes; a little softer and less coherent than 3.

Thus the effect of dilution and exposure to heat produced no difference in the rate of curdling on the addition of $\frac{1}{2}$ c.c. of rennet to $7\frac{1}{2}$ c.c. of the milk and water. The resulting curd was a little softer, breaking up more readily on shaking with water, in the more heated specimens.

The next table shows that by diluting the milk to a greater extent the rate of curdling is a little delayed. The softness and degree of coherence of the curd were modified by the amount of heat applied, to a certain extent, but chiefly depended on the degree of dilution.

TABLE LXXIX.

Effect of Rennet on Milk diluted with an equal bulk of Water.

1. Unheated milk . .		Curdled in 3 minutes. Less coherent than 1, Table LXXVIII.
2. Milk kept in water bath at 80° C. for	$\frac{1}{4}$ hour $\frac{1}{2}$ " $\frac{3}{4}$ " 1 "	All curdled in 4 minutes. The curds break up fairly readily on shaking with water.
3. Milk kept in water bath at 100° C. for . .	$\frac{1}{4}$ hour $\frac{1}{2}$ " $\frac{3}{4}$ " 1 "	All curdled in 4 minutes. The curds break up more readily than the corresponding ones of group 2.
4. Milk kept in autoclave at 110° C. for . .	$\frac{1}{4}$ hour $\frac{1}{2}$ " $\frac{3}{4}$ " 1 "	All curdled in 4 minutes. The curds are softer than those of group 3, and break up more readily, forming smaller flocculi.
5. Milk kept in autoclave at 120° C. for . .	$\frac{1}{4}$ hour $\frac{3}{4}$ "	Both curdled in 7 minutes. The curds were very soft and break up very readily on shaking; resembling those produced in milk heated to 110° C. for 1 hour.

TABLE LXXX.

Effect of Rennet on Milk diluted with twice its bulk of Water.

1. Unheated milk . . .	Curd produced in 3 minutes; less coherent than that of less diluted milk
2. Milk heated in water bath for 1 hour at 100° C. .	Curdling much slower; curd less coherent than 1.
3. Milk heated in autoclave for ¼ hour at 110° C. .	Curdling resembled that of 2.
4. Milk heated in autoclave for ½ hour at 110° C. .	Curdling resembled that of 3.

In this last series the same amount of rennet was added as in the series in Tables LXXVIII. and LXXIX., namely ½ c.c. to 7½ c.c. of the diluted milk.

The rate of curdling was considerably slower than that of less diluted milk, taking from 8–10 minutes in the heated specimens. The differences in the characters of the resulting curds are so slight that they may be regarded as unimportant.

Similar experiments were carried out to compare the effect of various diluents on the rate of curdling and the nature of the curd produced by the action of rennet. (Table LXXXI.)

The general conclusions from these experiments may be summed up shortly.

1. **The Action of Acetic Acid on the Curdling of Milk.**

(*a*) The size of the curd depends mainly upon the degree of dilution.

(*b*) After exposure to heat the acid produces a finer and more flocculent curd. This only holds good up to certain limits of temperature. Thus, by increasing the duration of the exposure up to an hour at temperatures of 80° C. and 100° C., the curd produced by the action of the acid became finer and

broke up into smaller flocculi on shaking with water. With an exposure for half an hour at 110° C., an even better result was obtained. On the other hand, more prolonged exposure at this temperature or a shorter exposure at a higher temperature rendered the curd more coherent.

(*c*) Similar results were obtained on subjecting milk, diluted in varying proportions, to these temperatures. The only difference was that in the diluted milk the coherence of the curd became more marked after exposure to 110° C. than at a lower temperature.

(*d*) Weak barley water acted as the best diluent, better than stronger barley water and lime water. Neither of the latter appears to produce better results than plain water.

Note.—Test-tube experiments are not always reliable as indications of what is going on in the stomach. When acid is added slowly to milk the curd is neither so quickly formed nor so solid as when it is added rapidly. A similar result is obtained with gastric juice. Further, the results vary with the degree of freshness of the milk used in the experiments. Old milk will form denser curds and more quickly with less acid (gastric juice, or HCl 0·02 per cent.) than new milk. Therefore the purer and fresher the milk, or in other words the less acid it is, the more easily is it digestible. From this it follows that the first step is to neutralise the acidity. There is a distinct relation between the number of microbes present and the acidity. Hence this degree of acidity becomes a fair test of the degree of care used in handling the milk and of its age.

TABLE LXXXI.

Effect of various Diluents on the Curdling with Rennet at different Temperatures.
Milk diluted with an equal quantity of the Diluent.

A. Unheated milk . .	with	1. Water. 2. Thin barley water 3. Thick „ „ 4. Lime water	The finest curd is produced when lime-water is used as a diluent, and the rate of curdling is slower. The results were better with thin than with thick barley water, and worst with plain water.
B. Milk heated in water-bath at 80° C. for periods of $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, and 1 hour .	with	1. Water 2. Thin barley water 3. Thick „ „	Rate of curdling and resulting curd presented no differences.
		4. Lime water	No change in colour; rate of curdling much slower, as 2 to 1. Resulting curd breaks up more readily than with other diluents.
C. Milk heated in water-bath at 100° C. for periods of $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, and 1 hour .	with	1. Water 2. Thin barley water 3. Thick „ „	Rate of coagulation a little more rapid with barley water than with plain water; except after exposure for one hour, when the reverse holds good. No appreciable difference in the resulting curds.
		4. Lime water	Results discarded on account of change in colour due to heat.
D. Milk heated in autoclave at 110° C. for periods of $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, and 1 hour .	with	1. Water 2. Thin barley water 3. Thick „ „	The rate of curdling was more rapid with plain water than with either kind of barley water. In the case of the latter diluent the longer the exposure to heat the slower was the rate of curdling.
E. Milk heated in autoclave at 120° C. for periods of $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, and 1 hour .	with	1. Water 2. Thin barley water 3. Thick „ „	The rate of curdling and the characters of the resulting curds were the same with all three diluents.

Clinically we find that babies digest milk better and in stronger mixtures in winter than in summer, and in the country than in towns, simply because it contains fewer microbes and is less acid. So, too, in gastric catarrh there is hyper-acidity and large curds are found in the stomach, leading to vomiting, colic and diarrhœa.

2. **The Action of Rennet Ferment on the Curdling of Milk.**

(*a*) Using considerable quantities of rennet curdling took place in much the same way, and at the same rate, after exposure of the milk at temperatures below boiling-point. The nature of the curd varied somewhat. In every case it was less coherent than that of fresh milk.

(*b*) The longer the exposure and the higher the temperature the more slowly did curdling take place, and the softer was the resulting curd, as judged by the readiness with which it disintegrated on gently shaking with water.

(*c*) Other experiments showed that the effect of heat was to render the milk less easily coagulated by the rennet. One drop of the ferment solution used was sufficient to convert 5 c.c. of unheated milk into a firm coherent coagulum in two to three minutes. On the other hand it required one cubic centimetre of the same solution to coagulate 5 c.c. of milk kept for half an hour at 120° C. Even then it took ten minutes to produce this result, and the curd was soft and broke up very readily. This effect of heat is exhibited at as low a temperature as 80° C., but of course not to such a marked extent.

(*d*) The effect of dilution with plain water and subsequent exposure to heat delayed the rate of

coagulation, and made the resulting curd softer in proportion to the amount of dilution, the duration of the exposure and the height of the temperature.

(*e*) As regards the different diluents, lime water rendered the rate of curdling of milk, unheated or heated to 80° C. for periods of half an hour to an hour, considerably slower and the curd much softer and finer on shaking with water. On exposure to a higher temperature than 80° C. the lime water causes a change in colour, passing from light yellow to brown. Milk thus altered in colour was not tested as to its coagulability. Barley water, whether thin or thick, does not appear to have any more effect than plain water in delaying curdling with rennet or in lessening the size and coherence of the curd, except to a slight extent in the case of unheated milk, and in milk heated to 110° C.

All these experiments tend to show that the essential factor in rendering cow's milk like human milk consists, not in exposure to high temperatures or the addition of diluents containing starch or lime, but in simple dilution with water to such an extent as to reduce the percentage of casein to what is present in human milk. In order to produce, on the addition of acetic acid, a curd such as is formed on adding this acid to human milk, cow's milk must be diluted with four or five times its bulk of water. In other words there is four or five times as much caseinogen in cow's milk as in human milk.

It is, however, quite clearly proved that the action of heat on milk modifies the properties of its caseinogen to a large extent, rendering it much less coagulable to the action of rennet. Possibly the change is due to the action of the heat on the lime

salts and not on the proteid. The practical outcome of these experiments supports very strongly clinical experience. Milk should be well diluted, heated, and lime water added in order to render it as much like human milk in its coagulability as possible. Thin barley water is the best diluent and a degree of heat not much, or not at all, above boiling-point. Lime water is more efficacious than plain water by virtue of its alkalinity.

The other cereal decoctions, such as oatmeal, wheatmeal, and whole or ground rice, have a similar effect to that of barley water. The effect is due to the amount of starch present. About 0·50 to 0·75 per cent. is the most useful. Probably also the faintly alkaline reaction of the decoction is also beneficial. Diastase, by acting on the starch, lessens its value as a diluent. Albumin water and gelatin solutions have no special value as diluents in their effect on coagulability.

CHAPTER XIV.

THE SUBSIDIARY METHODS OF PREPARING THE MILK OF COWS AND OTHER ANIMALS FOR THE USE OF INFANTS.

It has been shown that the great obstacle to the digestion of cow's milk by the infant lies in the coagulability of the caseinogen which is converted in the stomach into large coherent curds instead of into the small flakes produced in human milk under similar conditions. It has been further shown that sufficient dilution of the milk remedies this defect to a large extent, or even completely. But when the dilution is carried to such a degree as to render the curd minutely fine and flocculent the food becomes deficient in nutritive value. Several methods have been devised to remedy this defect in cow's milk as a food for infants and invalids. Those that depend on preparing the artificial food from various proportions of milk, cream, water and sugar, have been fully discussed. In the methods considered in this chapter the curd is altered in character, or prevented from forming, by various mechanical means or by pre-digestion.

Pre-digestion consists in the conversion of the proteids, either partially or entirely, into more

assimilable forms, such as peptones and allied bodies; a process analogous to the digestion of proteids in the stomach and intestines being carried out in the food before ingestion.

Different methods of pre-digestion are recommended by different authors.

1. **Eustace Smith's Method.**—Add five grains of pure pepsin and four drops of dilute hydrochloric acid to each ounce of milk: keep in a water bath at 100° F. until the mixture becomes clear. Neutralise by the addition of a little bicarbonate of soda and the milk is ready for use.

By this method of preparation the whole of the proteid matter in the milk is converted into peptones and albumoses. In order to limit the amount of pre-digestion it is only necessary to diminish the length of exposure to heat in the water-bath and, on removing from the bath, boil the mixture rapidly to destroy the ferment present.

2. **Robert's Method.**—Add half a pint of boiling water to a pint of fresh cow's milk; dissolve twenty grains of bicarbonate of soda in a little water and mix with two teaspoonfuls of Benger's Liquor Pancreaticus; mix the whole in a jug, cover it up and keep it warm under a "cosy" for one hour. Pour out into a saucepan and rapidly boil. Sweeten to taste by the addition of milk sugar. Cane sugar may be used instead of the milk sugar.

3. **Starr's Method.**—Put in a clean quart bottle five grains of Fairchild's Pancreatic Extract, fifteen grains of bicarbonate of soda and four ounces of cool filtered water; shake well and add one pint of fresh cool milk. Place in water so hot that the hand can be held in it for a full minute without

discomfort and leave in for thirty minutes. Remove and put on ice to stop further digestion and to prevent the milk from spoiling. Fairchild's *zymine* powders are very useful for this purpose. They are supplied in air-tight glass tubes, each containing five grains of the pancreatic extract and fifteen grains of bicarbonate of soda, sufficient to peptonise one pint of milk. Pancreatic extract is very hygroscopic and is liable to undergo changes if not kept in air-tight tubes.

Rotch's Method.—Put four ounces of cold, distilled or boiled water and one gramme of bicarbonate of soda into a clean glass jar; add one-fourth of a gramme of pancreatin (Ext. pancreatis) and twelve ounces of milk. Stand it in a vessel of water at 107° F. for seven to ten minutes. Cool at once and keep on ice.

The food produced by these means is less white in colour and differs a little in taste. On the addition of acid the curd produced consists of minute soft flakes or readily broken down masses of small size. At the point to which pre-digestion is carried the caseinogen and albumin are partly converted into peptone. Every succeeding moment of exposure to the action of the ferment lessens the amount of the proteids in the original milk, and increases the amount of peptone, until eventually the mixture becomes greyish yellow in colour, bitter tasting, and does not coagulate on the addition of acid. The proper moment for arresting the process is when the least bitterness is appreciable to the taste; the bottle should then be removed from the hot water and put on ice. Or the mixture should be poured into a clean saucepan and boiled. Partial peptonisa-

tion according to this method is generally sufficient to render the milk completely assimilable. For each feed for a child four to six weeks old give:

Peptonised milk	. .	1–1½ oz.
Water	. . . .	1–1½ oz.
Milk sugar	. . .	½ drachm.

Usually it is advisable to begin with equal parts of peptonised milk and water, and gradually increase the strength according to circumstances. The addition of cream is essential to render the food properly nutritious and like human milk. Or only the top milk, either a half or a third, should be used in order to ensure a sufficiency of fat in the food.

It is better to prepare each meal separately, when required, as the bitterness increases after the removal of the food from the hot water, unless it is very thoroughly boiled. For this purpose Starr recommends that it should be prescribed thus:

R.	Extracti pancreatis (Fairchild's) .	gr. ix.
	Sodii bicarbonatis	gr. xxiv.
	Misce et ft. pulv. xii.	

Add one powder to a nursing-bottle containing two ounces of water and two ounces of rich milk; shake; keep warm for half an hour before feeding and sweeten with half a teaspoonful of milk sugar.

5. **Fairchild's Peptogenic Milk Powder** can be used for this purpose and in a similar manner. It is sold in cans, with a small measuring tin, and is composed of pancreatin, bicarbonate of soda and a due proportion of milk sugar. The food is prepared thus:

Mix in a clean saucepan :

Milk	2 oz.
Cream	1 oz.
Water	2 oz.
Peptogenic milk powder	1 measure.

The mixture can be heated over a brisk flame to a temperature of about 100° F. to 140° F., and kept at this heat for six minutes. The temperature can be roughly estimated by the taste, the milk can be comfortably sipped, but it is more cleanly and more accurate to insert a suitable thermometer. Or the mixture may be heated slowly, with constant stirring, so that it is brought to boiling-point at the end of ten minutes and the process finally stopped.

The resulting fluid, prepared according to the latter method, is sterile, alkaline, and has the appearance of human milk. It is often spoken of as "humanised milk." It contains a proper proportion of fat, sugar, and salts, and proteids in a minutely coagulable and digestible form. Leeds's analysis shows the following composition :

TABLE LXXXII.

Composition of Peptonised Milk (LEEDS).

Water	86·2
Solids	13·8
Proteids	2·0
Fat	4·5
Lactose	7·0
Salts	0·3

No matter what method of peptonisation is employed the amount of pre-digestion of the proteid can be regulated by regulating the duration of the action of the ferment. The ferment acts more slowly at a low temperature and is destroyed by

boiling. By gradually reducing the length of exposure to the heat a return to the ordinary milk diet can be resumed, the amount of pre-digestion being gradually diminished. Partial pre-digestion does away with the need of any other method of attenuating the curd, and the presence of the bicarbonate of soda renders the addition of lime water unnecessary. The chief objection to the pre-digestion of milk is that it is an unphysiological process and that the resulting fluid does not require the same amount of digestive effort on the part of the child. Hence the digestive powers of the child are not developed by use or may be weakened by disuse. On the other hand a food is provided requiring a certain amount of digestive effort which may be proportioned to the capabilities of the infant and the state of its health. By gradually diminishing the amount of pre-digestion the child's stomach can be trained to do more and more work. It undoubtedly saves lives in suitable cases but it must be used with judgment and not continued for too long a period. Frequently it can be given for three or four months at a time without apparently doing any harm to the child or impairing the digestive functions.

Another objection to its use is that it requires a certain degree of intelligence in the mother or nurse and moderate trouble. Consequently it is not always practicable among the poor, whose children are the ones which chiefly require the application of subsidiary methods for increasing the nutritive value of their food and their digestive capacity. A third objection is that peptones and albumoses produced by this means may induce diarrhœa.

Its use is indicated in atrophic children whose digestive powers are very much weakened or even lost; for very young and delicate infants who cannot digest cow's milk modified and prepared as shown in previous chapters; and in febrile disorders interfering with the digestive capacity of the child. Giving a food which can be absorbed and assimilated increases the child's strength and co-incidently its digestive powers. As soon as natural digestion is established pre-digestion of the milk becomes unnecessary and should be discontiued.

One warning should be given. In the case of infants whom it is thought advisable to put on peptonised food, it is not sufficient merely to order the peptonising powders and tell the mother to peptonise the milk. The method should be clearly explained and the amount of the food, thus prepared, to be given at each meal, the number of meals in the twenty-four hours, and the intervals between each meal should also be clearly prescribed. Much of the failure from this method of feeding is due to neglect of these precautions. The doctor is satisfied with ordering peptonised milk and leaves the mother to regulate the feeds at her own sweet will and fancy.

Cream and Whey.—A simple method of diminishing the curd in milk is sometimes made use of in places where rennet is easily obtainable. It has no advantages over simple dilution with water except that the amount of lact-albumin and sugar in the milk is not diminished.

Allow a pint of milk to stand in a cool place for three hours. Separate the cream by skimming and put it on one side. Divide the milk into two equal

portions and add to one of them a small piece of rennet; put it on one side, covered up, until it is curdled and then strain off the whey. Mix the cream, the whey and the remaining portion of the milk, and heat rapidly. The mixture is then ready for use and differs from ordinary milk in containing half the percentage of proteid. It should be used soon, unless thoroughly boiled, or it may undergo curdling from some of the ferment having escaped destruction. A temperature of 65·5° C. destroys the rennet enzyme in whey. The mixture must not be heated above 69° C. or the albumin will be coagulated. In this method the amount of caseinogen in the milk is reduced to one-half, but no change is produced in the remaining caseinogen. It requires the addition of sugar to raise the percentage of this constituent to that which is present in human milk.

Or whey may be made separately and cream alone added in the required proportions. By this means we can obtain a mixture almost free from caseinogen.

Whey is prepared from fresh milk by the addition of a small quantity of rennet and keeping it at a temperature of about 100° F. for half an hour. The caseinogen is coagulated and squeezes out the fluid portion of the milk; much of the fat is entangled in the clot or curd. The fluid resembles the milk from which it is made, except that it is deficient in fat and proteid. The proteid remaining is the albumin. Consequently the fluid is easily digested, but is lacking in nutritive value, though it may be quite rich enough in proteid for some infants during the first three months of life or in atrophic

conditions. It can be given cold, in small amounts frequently. Wine whey can be made by adding an ounce of sherry to the pint.

Another method of preparation.—Heat half a pint of fresh cow's milk to 140–150° F. and add to it a teaspoonful of Fairchild's essence of pepsin or a teaspoonful and a half of wine of pepsin; mix by stirring and stand in a warm place until coagulation has taken place. Beat up the curd until it is finely divided and strain through muslin. A considerable portion of the finely divided casein and the fat passes through and remains in suspension. By this method a more nutritive fluid is made. (See also Appendix.)

TABLE LXXXIII.

Composition of Whey (König).

Proteid	0·86
Fat	0·32
Sugar	4·79
Salts	0·65
Water	93·38

An Average of 46 *Analyses.*

Hammarsten also gives the percentage of lact-albumin as 0·86; White and Ladd as 1·0.

Whey can be given separately, or with cream, or with milk. It is a useful means of increasing the amount of albumin in the food without increasing the caseinogen, and, by diluting the caseinogen, rendering it more digestible. A mixture of equal parts of milk and whey requires the addition of 4 per cent. of bicarbonate of soda to reduce the acidity to that of human milk (Monti). If the acidity is reduced the coagulum produced by rennet is neither as complete nor as firm.

Mechanical Methods of diminishing the size and coherence of the curd are rarely employed. A simple plan consists in curdling milk by means of some preparation or other of rennet. The clot is then taken and squeezed through a clean cheese-cloth bag or several thicknesses of fine muslin, or is passed through a fine hair sieve. The coagulated casein passes out in fine particles, and may be given shaken up in the fluid parts in the ordinary nursing bottle. When broken up in this way the casein particles do not again become blended into coherent masses.

Mechanical Attenuants.—Many diluents are added to milk with the object of rendering the curd produced by the action of gastric juice smaller and less coherent. The substances generally employed are farinaceous, gummy or gelatinous in character. Their action is purely mechanical, getting between the particles of casein during coagulation and preventing them running together into large coherent masses. Much greater value is ascribed to these methods of attenuating the curd than is warranted by experimental research.

Barley and oatmeal water are the two farinaceous preparations most commonly employed. These cereals contain less starch than wheat, and the starch in them is more readily transformed by the saliva. Oatmeal has a slight advantage over barley in containing more fat. It is the richest of the cereals in fat. It is also somewhat laxative, and therefore beneficial for overcoming the constipation so common in hand-fed infants.

In making barley water the "prepared barley" is generally used and is quite satisfactory for older

infants, but not so much so for younger ones. The whiter it is, the greater the percentage of starch which it contains. The best mode of preparation is to grind the whole barleycorns or oats, previously well washed and dried, in a coffee-mill, and by this means preserve the salts present in the husks. A teaspoonful of the ground meal may be boiled in half a pint of water with a small pinch of salt for a quarter of an hour, and then strained through a linen cloth or very fine muslin. For younger infants it must be made thinner; a teaspoonful of the ground meal or crushed barley, or oats, being put in a jug and half a pint of boiling water poured on it; it is then allowed to stand by the fire, with occasional stirring, for an hour, after which it is carefully strained. The value of the thin barley water as a diluent has been shown in the last chapter; the curd produced being finer and less coherent than when plain water was used. The difference is not very great, but is sufficient to warrant the use of it in cases of difficult digestion.

Rice water and dextrinised foods are useful in a similar way, but should not be used during the first three months of life, and are rarely advisable before the sixth month. An exception may be made in favour of rice water, which may be given as early as the first month, if made quite thin, and is valuable in the presence of looseness of the bowels.

Gelatin also is used by some physicians, but in my experience it is not necessary and has nothing specially to recommend it. To prepare it, put a square inch of plate gelatin into a half tumbler of cold water, and let it stand for three hours; turn it into a mug and stand it in a saucepan half full of

water and boil until the gelatin is dissolved. When cold it forms a jelly. One teaspoonful is sufficient to thicken a mixture of two ounces of milk and two of water.

Condensed Milk is very widely used as a substitute for human or cow's milk and, judging by the number of samples in the market, by the liberal distribution of advertisements, and by the frequency with which we find on inquiry that it has been given to the infant, the annual consumption must be simply enormous. Besides being made in this country it is imported in quantities of over five hundred tons a week. Among the hand-fed children of the lower classes it is very rare to find one who has not taken this substitute at some period or other of its infancy. The chief reasons leading to such extensive use are the ease and simplicity of the mode of preparation, the readiness with which the child takes and digests it, and its fattening properties. Its disadvantages are numerous and important and will be considered later.

Condensed milks vary considerably in the mode of preparation, and may be divided on this basis into three different groups.

TABLE LXXXIV.

A. Milk condensed with added cane sugar.
   1. Skimmed milk.
   2. Whole milk.
   3. Whole milk with added cream.

B. Milk condensed without the addition of cane sugar.
   1. Skimmed milk.
   2. Whole milk.
   3. Whole milk with added cream.

C. Fresh condensed milk, not canned, and with no added cane sugar; a variety not sold in this country.

The process of condensing consists in the exposure of the milk to a high temperature under pressure for an hour or more. It is then evaporated down *in vacuo* at a low temperature to one-third or one-fourth of its bulk. The high temperature is supposed to destroy all micro-organisms present and to alter the casein so as to render it more digestible, small light flakes being formed by the action of the gastric juice on mixtures made with water. Fresh condensed milk prepared in this manner can be kept in a refrigerator or ice-box for two to six days. It contains the same constituents as ordinary cow's milk and it can be given diluted in the required proportions. The objections to its use are that the degree of condensation varies and, what is of even more importance, no amount of dilution will render it identical in composition with human milk. If diluted sufficiently to reduce the amount of proteid to 1–2 per cent., both fat and sugar will be grossly deficient. Hence, if used, both cream and sugar must be added, and the process of preparing each feed becomes almost as complicated as if a suitable mixture were prepared from fresh cow's milk.

If fresh condensed milk is used it may be given in the following proportions :

Condensed milk . . .	1 oz.
Cream	1 oz.
Water	9 oz.
Milk sugar	3 drachms.

The variable composition of the tinned condensed milks in the market is shown in the following tables, the results of careful analyses made by Leeds :

TABLE LXXXV.

Composition of fifteen varieties of Condensed Milk. Analyses by LEEDS.

	Minimum.	Maximum.	Average.
Proteids	7·87	10·91	8·82
Fat	7·64	12·13	8·67
Lactose	10·00	16·98	11·66
Cane sugar	36·09	42·65	40·39
Ash	1·82	2·15	1·83
Milk solids	28·37	36·92	31·71
Fat in original milk	3·06	4·52	3·69
The average number of times condensed			2·27

The differences between milks condensed with and without the addition of cane sugar are considerable. Unsweetened condensed milk only keeps two or three days after the tin is opened.

TABLE LXXXVI.

Comparison between Condensed Milks (LEEDS).

	I. Milk and cane sugar. Mean of forty-one analyses.	II. Milk without added sugar. Anglo-Swiss milk.
Proteids	16·07	11·36
Fat	12·10	13·21
Lactose	16·62	15·29
Cane sugar	22·26	0·00
Ash	2·61	1·78
Total solids	69·66	41·64
Water	30·34	58·36

The analysis of the condensed milk as ordinarily used and prepared from the above samples is shown in the next table:

TABLE LXXXVII.

Condensed Milk as ordinarily given.

	No. I. sample with 8 times its weight of water (LEEDS).	No. II. sample with 5 times its weight of water (LEEDS).	Analysis of condensed milk as ordinarily used (MEIGS).
Proteids	2·01	2·27	0·868
Fat	1·51	2·64	1·095
Lactose	2·08	3·05	5·206
Cane sugar	2·78	0·00	
Ash	0·32	0·36	0·158
Total solids	8·70	8·32	7·327
Water	91·30	91·68	92·673

Thus it is evident that the moderate dilution of even the best samples of condensed milk renders the percentage of fat grossly deficient, and the amount of carbohydrate less than is present in good human milk. As a matter of fact the milk is usually given in a much more diluted form. Meigs's analysis shows a still greater deficiency in the proportion of fat and an insufficient amount of proteid. It takes so little condensed milk, about a teaspoonful to half a pint of water, to render the resulting fluid the colour of milk, that the weakness of the fluid is constantly overlooked. To a certain extent the deficiency of nutriment in the fluid is remedied by the increased amount taken, but reference to the above analysis of Meigs shows that the result is the ingestion of a disproportionate amount of sugar. Though the percentage amount of sugar in any one sample may not be too high the total amount taken during the twenty-four hours is excessive.

The Effects of Feeding on Condensed Milk.—The infant becomes fat, anæmic and lethargic.

The excess of sugar leads to the deposit of fat, and is liable to cause intestinal derangement from fermentative changes set up in the alimentary canal. The insufficient proportion of proteids leads to deficiency in blood and muscle. The alteration in the proteids and salts, as the result of the prolonged heating, renders the food deficient in the anti-scorbutic properties of fresh milk, and the child becomes liable to scurvy. But the most constant effect of all is the production of rickets. It is exceedingly rare to meet with an infant, brought up on condensed milk only, who does not become rachitic before the age of twelve months. In addition to this the child, though large and fat, is far from strong and has very little power to resist any form of intercurrent disease, such as attacks of gastro-enteritis or bronchitis, to both of which such infants are peculiarly liable.

Indications for its Use.—As a temporary substitute it may be given to infants while travelling, and when good cow's milk cannot be obtained. It may be used as a temporary food for atrophic infants with constant vomiting, or in illness from other causes. In such cases it is the degree of dilution that renders it more readily assimilable. By gradually adding very small quantities of cream and cow's milk the child's stomach can often be trained to digest suitably prepared cow's milk. It may be useful as a temporary food in cases of gastro-enteric disturbance and acute diarrhœa.

Objections to its Use.—Although condensed at a high temperature and canned, it is not always sterile. Cultivation experiments have frequently demonstrated the presence of micro-organisms. If

it is kept a long time it is liable to decompose. It may become slimy, cheesy or semi-solid; it may become quite solid or "go hard"; it may undergo putrefaction, in which case the tin becomes "blown." Any of these changes renders it dangerous as a food, and, needless to say, the people who commonly employ it as a food do not pay sufficient attention to the smell and taste. Tins that have once been opened are liable to decompose rapidly, especially in hot weather and where a refrigerator is not available.

Its composition varies very largely according to the milk from which it is made, the amount of condensation, the amount of cane sugar added, and the extent to which it is diluted before administration.

The composition of any one brand is not invariable, and depends on the honesty and skill or carelessness of the manufacturer, his foreman and employees. Although the tins first supplied to the public may contain milk of the quality advertised it is by no means uncommon for variations, which may appear to the manufacturer to be unimportant, to creep in when a good market has been established.

That a large number of condensed milks, prepared from skimmed milk, are supplied to the public is evident from a report by Bernard Dyer, published in the *British Medical Journal* for July 27, 1895. Seventeen samples analysed gave the following results:

TABLE LXXXVIII.

Percentage of Fat in Condensed Milk (DYER).

1. Marguerite Brand	0·42	9. Daily Brand	0·60
2. Tea "	0·48	10. Clipper "	0·73
3. Gondola "	0·48	11. Shamrock "	0·79
4. Cup "	0·49	12. Cross "	0·96
5. Goat "	0·56	13. Home "	1·02
6. Calf "	0·60	14. Handy "	1·49
7. Wheatsheaf "	0·62	15. Nutrient "	2·36
8. Swiss Dairy "	0·63	16 Cow "	2·84
17. As You Like It Brand	4·23		

All these, when compared with a sample of good condensed milk, show that they are condensed from skimmed or partially skimmed milk, and are therefore utterly unsuited for infant feeding.

The Anglo-Swiss Condensed Milk Company advertise a Milkmaid Brand, prepared in England, as containing proteid 8·8, fat 10·8, milk sugar 16·0, ash 1·7; and a Milkmaid Brand, prepared in Switzerland, containing proteid 9·7, fat 11·0, milk sugar 14·6, ash 2·3. Both varieties contain from 35–40 per cent. of added cane sugar. Nestlé's Condensed Swiss Milk is another good variety of the condensed milk with added cane sugar. It is advertised as containing 13·13 per cent. of fat, and is very similar to the Milkmaid Brand in composition.

If an unsweetened variety is required, the Ideal Brand of the Anglo-Swiss Company may be used. It is advertised as enriched 20 per cent. with added cream, and as containing 12·4 per cent. of fat. The Viking Brand is of similar type. It is stated to be prepared from absolutely pure fresh milk from cows grazed on Norwegian Highlands and free from added sugar or other substances. The cows, sheds, &c., and the process of condensation are under strict

supervision of veterinary surgeons and medical men. My experience of vegetation in the Norwegian Highlands would not lead me to expect the cows to yield a milk particularly rich in fat. The following analyses are given of this brand.

TABLE LXXXIX.

Composition of the Viking Brand of Condensed Milk.

	Chemical and Assay Laboratory.	*Lancet* Laboratory.
Water	66·0	67·59
Total solids	34·0	32·41
Proteids	8·9	—
Lactose	13·3	—
Fat	9·9	9·00
Salts	1·9	1·89

The milk appears to be condensed to a third of its bulk, and assuming this to be the case, the composition of the original milk should be:

Total solids	11·33
Proteids	2·97
Fat	3·30
Lactose	4·42
Salts	0·63

It is rather remarkable that the percentage of proteids in the milk of Norwegian cows should be so much lower than what obtains in that of English cows and that it is less than the percentage of fat present.

The public appear to think that the milk of cows of other countries is of better quality than that from the cows of our own land. Such is not the case. The well-fed cows of England, carefully bred and selected for their milk-yielding capacities, give a milk rich in fat, much more suitable for con-

densing than the milk of the Swiss and Norwegian animals.

In cases where it is considered advisable to give condensed milk, the administration of two feeds daily prepared with egg-albumin water (*vide* Appendix), instead of plain water, and the addition of cream to the other feeds, will counteract the disadvantages pertaining to it.

The milk of other animals than the cow is sometimes given to infants, for instance, the milk of the ass and the goat. More rarely the milk of the mare and ewe are given.

The milk of goats and ewes resembles cow's milk in the reaction to rennet ferment, and on the addition of acids, whereas that of the ass is very much like human milk.

Ass's Milk can be obtained from one of the dairy companies in London, a stud of milch asses being kept by them. It is supplied in sealed glass bottles to any part of the kingdom and is rather costly. One ass supplies enough milk daily to nourish three infants during the first three months of life, two for the fourth and fifth months, and one after this up to the ninth month. The milk can be given warm from the udder, or the babe can be put direct to the udder. It resembles human milk in reaction, chemical composition, and in its behaviour in artificial and natural digestion. The similarity is most marked in the characters of the caseinogen and in its relative proportion to the lact-albumin. It forms a curd in the stomach like that of human milk and possesses laxative properties which are, however, destroyed by boiling. According to most observers it is deficient in fat.

TABLE XC.

The Composition of the Milk of the Ass.

	Dujardin-Beaumetz.	Cheadle.	Meadows and Tanner.	Wynter Blyth.
Specific gravity	1032·1	—	1034·57	—
Water . .	91·40	90·5	89·012	91·17
Proteids . .	1·23	1·7	3·565	1·89 { Casein 1·09, Albumin 0·70, Peptone 0·10 }
Fat . . .	3·01	1·4	1·853	1·02
Sugar . .	6·93	6·4	5·046	5·50
Salts . .	0·45	—	0·524	0·42

According to three of these analyses the percentage of proteid is less than that of average human milk, while in the fourth it is almost the same as in cow's milk. In three of the analyses the percentage of fat is very much below that of human milk. The use of this milk is not necessary if good cow's milk can be obtained and suitably prepared. It may be useful as a temporary food, but should not be given for more than three months.

Tuberculosis is said to be unknown in the ass.

Goat's Milk is nutritious and pleasant to the taste, but has a strong odour, which disappears on boiling. One advantage it possesses over cow's milk is that there is less liability to the transmission of tuberculosis by its means, goats not being nearly as liable to this disease as cows are. It is said to agree better and to be more digestible than cow's milk in cases of intestinal disease. According to

Richter it contains less coagulable proteid and three times as much uncoagulable proteid as cow's milk. Burney Yeo states that it is richer than cow's milk in both proteid and fat. It is said to form a loose flocculent curd in the stomach like human milk. Judging from the various published analyses it is closely allied to cow's milk in percentage composition and does not possess any advantage over it. Testing it with acetic acid and with rennet I found that it curdled in the same way as cow's milk. Its composition is given in Table XCII.

Any one with a small plot of grass in the country or the suburbs of a town can buy a milch goat and keep it, at comparatively slight cost, to supply the food for the infant. The animal can then be dieted so as to render its milk suitable for the child. A goat is, however, a very destructive animal.

According to comparative analyses the milk of a goat is much more like that of a cow than like that of a woman.

TABLE XCI.

Comparative Analyses by GORUP-BESANEZ.

	Woman.	Cow.	Goat.
Water	88·9	85·7	86·3
Solids	11·1	14·3	13·7
Casein	3·9	4·8	3·40
Albumin		0·57	1·30
Fat	2·7	4·30	4·36
Sugar	4·4	4·03	4·00
Salts	0·14	0·55	0·62

All these analyses show that the proportion of proteid is equal to or greater than the proportion

TABLE XCII.

The Composition of Goat's Milk, as given by different Authors.

	Voelcker.		Meadows and Tanner.	Cheadle.	Gorup-Besanez.	König.	Dujardin-Beaumetz.	Wynter Blyth.
	Rich.	Poor.						
Water	82·02	84·48	84·49	85·6	86·3	86·91	86·952	87·54
Solids	17·98	15·52	15·51	—	13·7	—	—	12·46
Casein	4·67	3·94	5·514	4·5	3·40	2·87	4·427	3·00
Albumin					1·30	1·19		0·70*
Fat	7·02	6·11	5·687	4·1	4·36	4·09	6·068	4·20
Sugar	5·28	4·68	3·691	5·8	4·00	4·45	4·856	4·00
Salts	1·01	0·79	0·618	—	0·62	0 96	0·910	0·56
Sp. gr.	—	—	1033·530	—	—	—	1033·850	—

* Including 0·08 per cent. of peptone.

present in cow's milk. The relative proportions of caseinogen and albumin are also much the same as I found in cow's milk, viz., about two to one. Richter's view that the amount of uncoagulable proteid is in excess is not confirmed by these analyses. The percentage of sugar is almost identical with that present in cow's milk. The proportion of fat is on the whole somewhat greater than that of average cow's milk, but not greater than that of the milk from many cows specially fed for the supply of infant's milk.

Kephir.—This is a modification of cow's or goat's milk, resulting from a process of fermentation analogous to that to which mare's or ass's milk is subjected in making koumiss. It has been used for ages among the Caucasian tribes, and in 1879 the ferment was obtained by Russian physicians and investigated by them, and subsequently by the Germans. Barry states that "the kephir grains are in their first living state white bodies, usually of an irregular, roundish form, equal to, or exceeding, a walnut in size, chiefly composed of rod-shaped bacteria and numerous groups of sprouting fungi, living and growing in company with the bacteria. The kephir ferment consists then mainly of a mass of micro-organisms procured from the dirty skin milk-sacks of an uncivilised and filthy people." According to Taylor there are three kinds of organisms, the bacillus caucasius, saccharomyces mycoderma, and bacillus lactis, found in the "kephir beans," small masses of dried ferment held together by a gelatinous substance.

The mode of preparation is described by Flügge as follows: "Two methods may be employed. In the

first, the dry brown *kefir korner* of commerce are allowed to lie in water for five or six hours until they swell; they are then carefully washed and placed in fresh milk, which should be changed once or twice a day until the *korner* becomes pure white in colour and when placed in fresh milk quickly rise to the surface, in twenty to thirty minutes. One litre of milk is then poured into a flask and a full tablespoonful of the prepared *korner* added to it. It is allowed to stand open for five to eight hours; the flask is then closed and kept at 18° C. It should be shaken every two hours. At the end of twenty-four hours the milk is poured through a fine sieve into another flask, which must not be more than four-fifths full. This is corked and allowed to stand, being shaken from time to time. At the end of twenty-four hours a drink is obtained which contains but little carbonic acid or alcohol. Usually it is not drunk until the second day, when, upon standing, two layers are formed, the lower milky and translucent, the upper containing fine flakes of casein. When shaken it has a cream-like consistence. On the third day it again becomes thin and very acid.

"The second method is used when one has a good *kefir* of two or three days to start with. Three or four parts of fresh cow's milk are added to one part of this and poured into flasks which are allowed to stand for forty-eight hours with occasional shaking. When the drink is ready for use a portion (one-fifth to one-third) is left in the flask as ferment for a fresh quantity of milk. The temperature should be maintained at about 18° C.; but at the commencement a higher temperature is desirable. The *korner*

should be carefully cleaned from time to time and broken up to the size of peas. The cleaned *korner* may be dried upon blotting-paper in the sun or in the vicinity of the stove; when dried in the air they retain their power to germinate for a long time."

Properly made it is thick, of uniform consistence, and free from lumps. It contains more or less carbonic acid, which forms bubbles on the surface, and is sour but not acid. It resembles butter-milk, but is less acid. If kept for two or three weeks it becomes very acid, and contains a large amount of carbonic acid. It is a partially digested milk, containing less casein and milk sugar than fresh milk. It contains abundance of proteoses, and, according to some observers, peptones also. The fermentation of the milk sugar leads to the formation of alcohol, carbonic acid, and lactic acid, and the longer the process is continued the smaller the amount of unfermented sugar. Small amounts of succinic, butyric, and acetic acids are formed. Comparative analyses, quoted by Dujardin-Beaumetz, show in what respects it differs from cow's milk and koumiss :

TABLE XCIII.

	Cow's Milk.	Kephir.	Koumiss (Analysis by Hartier).
Proteids	4·8	3·8	1·12
Fat	3·8	2·0	1·20
Lactose	4·1	2·0	2·20
Lactic acid	0·0	0·9	1·15
Alcohol	0·0	0·8	1·65
Water and salts	87·3	90·5	91·83

The advantages claimed for it are that it is both tonic and stimulant, by virtue of the alcohol and carbonic acid; that it is more easily digested on account of much of the casein being converted into soluble forms of albumin; that the lactic acid exerts a germicidal action and, arguing from the fact that this acid is found in the stomach during the digestion of milk, is of assistance in the digestion of milk casein. As a rule children do not like it at first, but if a little sugar is added they take it readily and soon prefer it to ordinary milk. Temporary diarrhœa may be set up when first it is given.

It is asserted to be of great value in diarrhœal affections and in simple atrophy; the carbonic acid increasing glandular activity. For infants under one month of age it must be diluted with one-third of water, but at the age of six weeks it may be given undiluted. It should constitute the only food of the child and be given fresh out of an ordinary feeding-bottle. Many physicians object to its use on account of the quantity of lactic acid which they regard as dangerous. According to Brush this acid is a forerunner of putrefaction.

Alexander Levy in 1886 found that effervescing alcoholic kephir can be obtained without the use of kephir grains, by bottling milk and shaking it well while it is turning sour. The fluid thus prepared contained double the amount of alcohol present in kephir.

When we consider the amount of care and attention devoted to milk in order to supply the child with a food as nearly as possible devoid of micro-organisms it seems very unreasonable to use a food

prepared from dirty masses of micro-organisms and containing large quantities. If alcohol is required for the child it can be given in a much more simple and satisfactory way and the amount easily regulated. If carbonic acid is thought advisable it is much more cleanly and scientific to prepare a milk mixture, humanised if necessary, containing an amount of proteid suitable to the age and digestive capacity of the child, and then charge it with carbonic acid in the same way that soda water is made.

Matzoon is a fermented drink in extensive use among the natives of Asia Minor. It is probably made by the action of a yeast. The milk is first boiled. It is allowed to ferment for twelve hours. If differs from the cow's milk from which it is prepared in containing less milk sugar, some of it having been converted into carbonic acid, lactic acid and alcohol. The casein is not rendered more soluble and forms large insoluble curds.

Koumiss or Kumyss is an alcoholic drink prepared from mare's or ass's milk by fermentation with kephir grains. It is used largely by the Tartars and the Khirgis tribes, and other nomadic tribes of the South-eastern Steppe country of Russia. It is a milky-looking frothy liquid with an agreeable slightly acid taste. The casein is said to be in a fine state of sub-division. Its composition varies according to the duration of the process of fermentation, as can be seen on referring to the following analyses given by Stange and an independent analysis made at Moscow:

TABLE XCIV.

Composition of Koumiss and Mare's Milk (STANGE).

	Mare's Milk.	Koumiss. Duration of Fermentation.				Koumiss. Moscow Analysis.
		6 hrs.	18 hrs.	30 hrs.	4 days.	2 days.
Proteids . .	2·3	2·25	2·26	2·00	1·60	1·12
Fats . .	1·9	1·89	2·00	1·90	1·90	2·05
Lactose . .	5·1	1·88	1·63	0·00	0·00	2·20
Salts . .	0·5	0·45	0·40	0·40	0·40	0·28
Lactic acid .	—	0·39	0·56	0·64	0·64	1·15
Alcohol . .	—	1·85	1·95	3·00	3·00	1·65
Carbonic acid .	—	0·38	0·60	0·70	1·10	0·70

A modification of koumiss is made by various dairy companies from cow's milk, but is very different from the true article; it is made by the addition of sugar and yeast, the use of kephir grains having been soon abandoned.

Koumiss has a slight laxative action which can be arrested by the addition of lime water. It may be given to relieve constipation and it is a mild diuretic. It generally contains more alcohol than kephir.

CHAPTER XV.

PROPRIETARY FOODS.

A LARGE number of so-called "Infant's Foods" are on the market, but only reference will be made to those most commonly used in this country. In almost every variety there is a large quantity of carbohydrates, usually in the form of starch. In some the starch is partially changed into other forms of carbohydrate, such as dextrin and maltose, by the action of malt diastase or other ferment. Some contain a considerable amount of cane sugar. Many of the foods have a basis of condensed milk.

The value of starch as a food for infants has been hotly discussed by many writers. No form of carbohydrate, except lactose, is present in the milk of woman or any other mammal. The maternal secretion is the natural and the best food for the young animal during the first few months of its life. *Primâ facie*, therefore, it is unlikely that starch will prove a suitable food for young infants. It is not essential to the infant that the carbohydrate it receives should necessarily be in the form of milk sugar, for in artificial feeding this carbohydrate can be replaced by cane sugar without injury to the child. Cane sugar is, however, a much more soluble and digestible form of carbohydrate than starch; the

latter has to undergo conversion in the alimentary canal into soluble forms of carbohydrates, such as dextrin, maltose, and dextrose. The digestibility of starch comes therefore to depend upon the power possessed by the infant of converting it into the soluble forms. This power depends upon the secretion and activity of the amylolytic ferments in the salivary glands and pancreas. According to Charles Reichert and Professor Flint, jun., another ferment, capable of inverting starch, is secreted by the epithelial cells lining the buccal surface and the intestinal tract. Heat and moisture alone will create a small amount of inversion.

Salivary secretion is very scanty in young infants, and is rarely appreciable before the age of two or three months. About 1 c.c. is secreted in twenty minutes at the end of the first month. During the third month the quantity amounts to 1 c.c. in two minutes. Nevertheless the secretion has a distinct diastasic effect during the first month of life, and increases in potency with each succeeding month. It reaches its full development by the end of the first year. Jacobi found that infusions of the parotid after death exercised a similar action. Zweifel found that an infusion of the parotid from an infant seven days old exerted a distinct diastasic action in four minutes: an infusion of the parotid of an eighteen-day old infant, who had died of gastro-enteritis, gave a like result at the end of three-quarters of an hour. Other observers have obtained similar results, and it may be accepted as an established fact that the salivary secretion of even the youngest infant possesses a slight amount of diastasic power.

The activity of the salivary ferment is not confined to the short period of time that the food remains in the mouth, but continues in the stomach until it is stopped by the secretion of hydrochloric acid. The process may continue in the stomach for half an hour or even longer. According to Hayem the gastric glands of the new-born infant do not secrete any hydrochloric acid, although the parietal cells are present. Even when it is secreted the amount is small and is probably neutralised rapidly.

The action of the salivary ferment on starch depends largely on the variety of starch ingested. Solera found that potato starch was changed most rapidly; then wheat, Indian corn, and rice starch, in order of rapidity. Malay found that potato paste was changed the most rapidly, then oat, barley, and wheat starch in the order given. The latter observer also found that boiled starch was much more quickly changed than unboiled. Heubner experimented on infants, the youngest aged seven weeks. Known quantities of starch were given and the amount of unchanged starch present in the fæces was estimated by Carstens. In all cases considerable quantities were absorbed. This partial conversion took place to a greater extent in some infants than in others.

The pancreatic secretion exerts a much more powerful amylolytic action than the salivary. According to Korownin of St. Petersburg, it is not until the end of the third month of life that this secretion has any appreciable action on starch. Jacobi asserts that the diastasic power of the pancreas begins with the fourth week, and remains very feeble up to the end of the first year. He found that infusions of the pancreas of infants who had lived three weeks

produced no change in starch. It may be granted, therefore, that the pancreatic secretion possesses a feeble amylolytic power by about the third or fourth month of life. But the presence of a function does not necessarily imply that it ought to be used and certainly, during the period of development, it will become impaired if it is taxed to any great extent. Jacobi, with his wide and long experience, is strongly in favour of the administration of starchy fluids to the youngest infants. He recommends that the milk should be diluted with four or five times its bulk of barley or oatmeal water and has got excellent results by such means. With all respect to such a great authority I cannot help thinking that the success of his method of feeding is due, not to the addition of starch, but to the dilution with fluid. It has been shown that the percentage of caseinogen in cow's milk is four or five times greater than in human milk. It has been shown that the reason infants cannot digest cow's milk is on account of the high percentage of caseinogen. Diluting milk with four or five times its bulk of water will reduce the percentage of caseinogen to a digestible minimum. If carbohydrate is wanted it is better to add it in an easily soluble and assimilable form during the early months of life, namely, in the form of milk sugar or cane sugar.

In weak solution my experience has shown that barley water is, as a rule, non-injurious to even the youngest infants. This is not invariably the case. Some infants, even up to the age of six or seven months, will not digest milk diluted with barley water, but will thrive on milk diluted with plain water.

Undigested starch is liable to fermentation and formation of irritant products which may interfere with digestion and absorption by the production of catarrh of the intestinal mucous membrane.

The presence of an excess of starch in the food may interfere with nutrition. One of the essential factors in the maintenance of perfect nutrition is the rapid destruction and removal of waste products. This is brought about by oxidation and, seeing that sugar, formed in the digestion of starch, has a greater affinity than proteid matter for oxygen, an excess of sugar will appropriate the oxygen which would otherwise be used in the oxidation of waste products.

Starchy foods are not good culture media for proteolytic bacteria and have consequently a certain aseptic influence. In certain pathological conditions, such as acute gastro-enteritis, thin gruel sometimes replaces milk with advantage. For such use rice flour or arrowroot is the best, in the proportion of one to two tablespoonfuls to a pint of water. The meal must be rubbed up with cold water into a paste and boiling water poured on while stirring ; it should then be boiled for half an hour.

Barley or oatmeal water should, as a rule, be added to the diet at the age of six months, and the strength of the solution gradually increased up to the end of the first year. Cornflour may then be given, also crackers, biscuits, and stale bread. When the child is old enough to run about it can digest, and requires considerable quantities of starchy foods. The carbohydrates are the great source of muscular energy, supplying the fuel for the activity of the engine. Care, however, must be taken that the child

gets sufficient nitrogenous food, or it becomes fat, flabby, pot-bellied, and lethargic. Many children of the lower classes in large towns, especially in the south of England, suffer in this respect. The baker's bread, their main article of diet, is often made from wheat flour mixed with considerable quantities of potato starch, and is not as rich in bone- and muscle-forming constituents as the home-made bread eaten in the north of England.

In proprietary foods starch is usually the predominant form of carbohydrate present. In some it is converted by the mode of preparation into maltose and dextrins. The value of such a food depends primarily on the age of the child, and secondarily on the amount of unconverted and converted starch present.

Many objections can be urged against the use of proprietary foods for infants. They are quite unnecessary, for, as has been shown above, a child can be successfully brought up on cow's milk suitably diluted and prepared. If more fat is wanted in the diet cream, butter, margarine, olive oil or cod-liver oil can be added. If there is deficiency of digestible proteid the food can be peptonised, more or less, or egg-albumin given. If carbohydrate is wanted milk sugar, cane sugar, and any number of starchy foods are at our disposal. The amylolytic functions of infants are not sufficiently developed for the entire digestion of those containing starch. The excess of carbohydrates, in those foods containing altered starch, leads to fatness rather than to health and strength. The foods may vary in composition from year to year. On account of their greater production the original qualities may not be maintained,

cheaper methods and materials being employed. They take the place of more valuable food.

It cannot be too strongly impressed on mothers that a bulky food is not necessarily a nutritious one. It must also be remembered that the composition of a proprietary food, as described on the tin, is by no means the same as that of the diluted mixture given to the child.

The mortality among infants brought up on artificial foods is enormous. In Berlin, where the death certificates of infants under one year must state whether the child was fed on the breast or by hand, more than three-fourths of ten thousand deaths were in the hand-fed. Many of these took proprietary foods.

I am strongly of the opinion that the mortality among infants would be enormously diminished if it were possible to abolish all these preparations or to render it illegal for a mother to give them to her infant, if under one year of age, except on medical advice. The latter proposal would, however, not be nearly so efficacious as the former, for it is by no means uncommon for medical men to recommend these foods for very young infants, without having the least regard to the age of the child, the composition of the food, the amount to be given, or the physiological requirements of the patient. Needless to say some infants are met with who appear to digest such foods with impunity and even with advantage, but they are rare exceptions, and the fine fat, blooming children of the manufacturers' advertisements only exist in the imagination or, when seen in the flesh, are simply fat and rachitic. That the disadvantages are not greater and more

apparent, is merely due to the fact that the maker usually recommends his food to be given mixed with cow's milk. There is no doubt that rickets and scurvy are often due to the prolonged use of these preparations. Some of them are of temporary value in certain pathological conditions and can be used by the physician with very great advantage.

Sugar, in the form of cane sugar, is often added to proprietary foods on account of its preservative properties. This is especially the case in condensed milks, already referred to. It is supposed to undergo lactic acid fermentation less readily than milk sugar, and it is cheaper and purer. It readily undergoes alcoholic fermentation.

Classification of Proprietary Foods.

Group 1. Foods prepared from cow's milk.

a. Condensed milk, without added sugar.

b. Condensed milk, with added sugar.

c. Peptonised milk—*e.g.*, Loeflund's Peptonised Milk, Backhaus' Milk, &c.

d. Milk in which the amount of casein has been reduced and lact-albumin, albuminates, or peptones added—*e.g.*, Somatose Milk, Rieth's Albumose Milk, &c.

Group 2. Prepared from cow's milk and modified cereals; the starch unchanged or partially converted into dextrins, &c.

a. Containing much unchanged starch—*e.g.*, Nestlé's, Anglo-Swiss, &c.

b. The starch largely converted into soluble carbohydrates, such as maltose and dextrins—*e.g.*, Allen and Hanbury's.

c. Milk foods containing partially peptonised milk or ferments which act on the addition of warm milk, and much partially or entirely converted or unconverted starch—*e.g.*, Benger's (prepared with milk), Carnrick's, Horlick's Malted Milk.

Group 3. Prepared from modified cereals only.

a. The starch unchanged—*e.g.*, Robinson's Prepared Barley, Frame Food, Chapman's Entire Wheaten Flour, Ridge's Food, and Neave's Food.

b. The starch partially changed by the action of malt diastase—*e.g.*, Savory and Moore's Food.

c. The starch completely changed—*e.g.*, Mellin's Food, Horlick's Food.

Many of these foods have been analysed by Leeds; his results are given in Table XCVI. (p. 308). Under the head of soluble carbohydrates are included maltose, cane sugar, milk sugar and dextrins.

It is noticeable in the same table that baked flour differs very little from ordinary wheat flour, only a small amount of the starch being converted into soluble carbohydrates. A preparation from flour, known as "flour ball," is sometimes highly spoken of. It is prepared from wheat flour tied tightly up in a pudding cloth and boiled for several hours. Leeds analysed flour before and after boiling for fifteen hours a day on five successive days, seventy-five hours in all, and found no appreciable difference in the percentage of unconverted starch and soluble carbohydrates before and after the process. The fat, however, was dissolved out.

Frame Food Extract is widely advertised as the extracted nutritious product from bran of wheat. According to the *Lancet* analysis it contains much ash, rich in phosphates; much dextrin and little starch; and much albuminoid.

TABLE XCV.

Composition of Frame Food (as advertised).

Albuminoids			22·0 per cent.
Phosphates	Phosphoric acid	3·68	10·5 ,,
	Potash	4·22	
	Iron, &c.	2·77	
Carbohydrates			58·0 ,,
Water			9·5 ,,

TABLE XCVI.

The Composition of various Proprietary Foods.

Name of Food.	Water.	Albuminoids.	Fats.	Starch.	Soluble Carbohydrates.	Ash.	Gum, Cellulose, &c.	Remarks.
Wheat flour .	9·02	7·47	1·01	76·07	5·66	—	—	—
„ baked .	7·78	undetermined	0·41	67·60	14·29	—	—	Albuminous substances are more soluble.
Robinson's Patent Barley	10·10	5·13	0·97	77·76	4·11	1·93	1·33	—
Ridge's Food .	9·23	9·24	0·63	77·96	5·19	0·60	—	Cane sugar, 2·20. Grape sugar, 2·40. Almost pure flour.
Nestlé's Food .	5·00	11·00	4·25	36·86	40·91	1·70	0·28	The soluble carbohydrate is almost all cane sugar.
Anglo-Swiss .	6·50	10·26	4·91	29·48	46·43	2·02	0·40	Much cane sugar.
Franco-Swiss .	4·43	13·00	3·70	30·86	46·09	1·42	0·50	„ „
American-Swiss .	5·68	10·54	5·81	30·00	45·35	1·21	0·41	„ „
Malted milk .	2·18	15·83	5·30	5·57	66·99	3·13	—	—
Wells' and Richardson's	7·76	11·85	1·64	36·43	39·00	2·61	0·71	—
Savory and Moore's	8·34	9·63	0·40	36·36	44·83	0·89	0·44	Much grape and cane sugar.
Horlick's . .	9·70	10·43	0·34	—	76·83	2·20	0·50	—
Mellin's . .	12·37	10·07	0·18	—	68·18	3·75	5·45	About half the soluble carbohydrate is grape sugar.

The jelly is a mixture of the extract with cane sugar, and may be used as jam. The food is a mixture of the extract with baked flour and sugar. It contains much gluten and unaltered starch. These preparations are suitable for infants and children after the age of twelve months, but not before.

Ridge's Food, as the analysis shows, possesses no advantages over any other starchy food. It is only suitable after the first nine months of life, and is of no more value than ordinary wheat flour, barley or oatmeal. It should certainly not be given at the early age at which so many infants get it.

Neave's Food is similar in character and much the same in composition. Other foods of like nature are Chapman's Entire Wheat Flour; Robinson's Patent Barley, made from ground pearl barley; Scott's Oat Flour and Robinson's Groats, made from ground oats. Falona is a food of mixed flours of wheat, barley, oats and beans.

Nestle's Food consists of condensed skimmed milk, wheat flour, which is said to be baked, sugar and salts. The flour is converted into a dough, baked, pounded up into a powder, mixed with condensed milk in a definite proportion, and dried by a slow heat at a moderate temperature. It is claimed that the starch is partly converted into dextrin by the baking and the gluten rendered more soluble. Given diluted with six parts of water it contains less than two per cent. of proteid, between six and seven per cent. of soluble carbohydrates and a similar amount of starch, and a very small proportion of fat, less than one per cent. Its

defects, therefore, consist in the large amount of unconverted starch and the small amount of fat. For an infant under two months of age the manufacturer directs that one tablespoonful should be boiled for a few minutes with two tablespoonfuls of water. The composition of the resulting fluid can be gathered from the above analysis. Properly diluted it is deficient in both fat and proteid, so no infant can be expected to thrive on such a food, even if it can digest and utilise the unconverted starch.

Other farinaceous foods of the same character, having a basis of condensed milk and being prepared in a similar manner, are the Anglo-Swiss, Franco-Swiss, and the American-Swiss. In chemical composition they closely resemble Nestlé's Food, and the same objections to their use hold good. Such foods have a slight advantage over ordinary flour by reason of the amount of soluble carbohydrates which they contain, and the presence of a small amount of fat.

Muffler's Food is very similar. It is made of desiccated milk, powdered white of egg, powdered wheaten flour, and lactose.

Wells and Richardson advertise a lactated food, which is not a true lactated food, inasmuch as it is not prepared with milk. It is said to contain fifteen per cent. of malt diastase, obtained from the finest quality of barley malt without the aid of heat, and that this retains its full diastasic power. Leeds, however, found no such diastasic action when the food was brought into solution. According to the advertised analysis it contains no starch, whereas more than one-third of it is starch. The advertised

analysis and the results obtained by Leeds are worth quoting as showing how little reliance can be placed on such advertisements.

TABLE XCVII.

Wells and Richardson's Lactated Food.

	ADVERTISEMENT.	LEEDS.
Water	not indicated	7·76
Fat	,,	1·64
Malto-diastase	15·00	not found
Cane sugar	25·00	29·64
Soluble carbohydrates	39·00	39·00
Starch	not indicated	36·43
Albuminoids	16·25	11·85
Ash	1·98	2·61

Even the advertised analysis shows that the food is unsuitable for infants, on account of the deficiency in fat. It might be taken by older children, when they can digest ordinary farinaceous food without injury.

Mellin's Food is widely advertised and largely used. It is prepared from barley and wheat flour by means of diastase and contains a large amount of converted starch in the form of dextrins, maltose and dextrose. In some samples the starch is completely absent. It is, therefore, a completely malted food consisting of soluble carbohydrates and is indicated if there is any need for giving additional carbohydrates. According to the directions on the label it should be given with a considerable quantity of milk. The advertisers publish the adjoined analyses of the mixture, prepared according to their recommendation, and comparative analyses of human milk :

TABLE XCVIII.

1. *Analysis of a Mixture of Mellin's Food, Water, and Cow's Milk, prepared in accordance with the directions, viz.—*

Mellin's Food, 1 tablespoonful, or ½ oz.; Water, 2 oz.; Cow's Milk, 6 oz.: or Mellin's Food, 5·88; Water, 23·53; Cow's Milk, 70·59. Total, 100·00.

			Water	Sugar	Nitrogenous matter	Butter	Salts
MELLIN'S FOOD 5·88 (Fresenius' Analysis)	Water .	·78	·78				
	Sugar .	4·27		4·27			
	Nitrogenous matter	·57			·57		
	Salts . .	·26					·26
Water . 23·53	Water	. 23·53	23·53				
Cow's milk 70·59	Water	. 61·03	61·03				
	Sugar	. 2·68		2·68			
	Butter	. 2·54				2·54	
	Casein	. 3·88			3·88		
	Salts .	. ·46					·46
Totals . 100·00		100·00	85·34	6·95	4·45	2·54	·72

Leeds has also published analyses:

TABLE XCIX.

	Mellin's Food.		A Mixture.*
Soluble carbohydrates . .	68·18	...	4·11
Proteids	10·07	...	1·89
Fat	0·18	...	1·86
Cellulose, gum, &c. . . .	5·45	..	—
Salts	3·75	...	0·43
Total Solids	87·63	...	8·29
Water	12·37	...	91·71

* Food, 3 parts; milk, 47 parts; water, 50 parts.

No starch was found in the sample examined. Even when prepared with a large quantity of milk, as recommended by the makers, it is much deficient in fat and contains an excess of proteid. If pre-

TABLE C.

2. *Comparative Analyses of Human Milk and Mellin's Food.*

	HUMAN MILK.								Mellin's Food as above.
	Analyses quoted by TANNER.				WURTZ'S.	LEEDS' analyses of 43 samples.			
	Fair.	Dark.		Average.	Average.	Minimum.	Maximum.	Average.	
Water	89·20	85·33	88·90	87·81	87·02	83·34	89·09	86·76	85·34
Sugar	5·85	7·12	4·36	5·78	7·05	5·40	7·92	6·99	6·95
Butter	3·55	5·48	2·69	3·90	4·06	2·11	6·89	4·01	2·54
Nitrogenous matter	1·00	1 62	3·92	2·18	1·67	0·85	4·86	2·05	4·45
Salts	0·40	0·45	0·13	0·33	0·20	0·13	0·35	0·21	0·72
	100·00	100·00	100·00	100·00	100·00				100·00

Quoted from Advertisement.

pared with a smaller amount of milk and more water, so as to reduce the percentage of proteid, it becomes, *vide* Leeds' analysis, deficient in both fat and carbohydrate.

It is a very fattening food and possesses laxative properties, in some cases giving rise to diarrhœa. If an artificial food is thought necessary this is one of the best kinds to begin with. In small quantities it is often beneficial after the sixth month of life. Containing no unchanged starch and a large amount of soluble carbohydrates, it is digested and absorbed with comparative ease. It can be given at a much earlier period of life than a food containing unconverted starch.

Benger's Food, according to the advertisement, is not pre-digested; it consists of a highly nitrogenous wheaten meal, cooked and impregnated with a suitable proportion of the natural digestive ferments of the pancreas. These ferments, on mixing with warm milk, convert the carbohydrates into soluble dextrins and sugar, and partially peptonise the proteids. The fat is unaffected. The objections to its use are that the mixtures made from it are deficient in fat and the amount of pre-digestion of the starch and casein cannot be accurately regulated. In the mixtures given a considerable amount of the starch is unconverted. It is by far the most useful food for marasmic infants over six months of age and during illness from any other cause. A baby aged nine months, after an attack of meningitis of between two and three months' duration, during which it became very wasted, gained no less than four pounds in sixteen days on a diet of Benger's Food and milk.

It is prepared by mixing one teaspoonful with two ounces of cold milk and then adding hot milk and water; allowed to stand for fifteen minutes and finally boiled. Of course it can be made weaker or stronger as desired.

Savory and Moore advertise a "Best Food for Infants," in which the proteids are not pre-digested but are rendered easy of digestion. Malt diastase is present and converts the starch into dextrin and maltose at the time of mixing. The fat and phosphates of the wheat and malt are retained, and there is no fermentable sugar. When mixed with cow's milk it is supposed to prevent the troublesome curdling which takes places when cow's milk is given alone. This food contains a considerable quantity of starch, and may be given to infants who have been taking Mellin's Food before passing on to a pure farinaceous food. It contains no appreciable amount of fat.

Carnrick's Food is advertised as a soluble food prepared from milk and wheat. The milk is sterilised and partly digested with fresh extract of pancreas. The starch of the wheat is converted into soluble starch and dextrin. Milk sugar is added in the required proportion to make the total carbohydrates equal to the amount present in human milk. As a matter of fact a great part of the starch is unchanged and insoluble, and therefore the bulk of the food is insoluble. The proteids are deficient and the amount of fat scarcely appreciable.

Horlick's Malted Milk is supplied as a dry powder ready for use on the addition of water. It is stated to be a combination of pure, fresh cow's milk, wheat (rich in phosphates), and a specially

malted barley; free from starch, animal pepsin, and vegetable fats. The milk is said to be acted on by diastase so as to be partially pre-digested. It is deficient in fat and contains dextrin.

TABLE CI.

Comparative Analyses of Horlick's Malted Milk.

	The Company.	The *Lancet.*	Human milk: all but 4 % water removed.
	per cent.	per cent.	per cent.
Water . . .	3·27	2·21	4·00
Proteids . .	22·26	21·85	23·39
Fat . . .	6·78	8·40	23·39
Sugar . . .	46·63	} 63·59	46·78
Dextrin . .	17·16		0·00
Ash . . .	3·90	0·95	2·44

The addition of ten parts of water to one of the food will render the amount of proteid and carbohydrate much the same as in human milk, but the fluid will be so very poor in fat as to be unsuitable for infants. It may be used under the same conditions as Mellin's Food.

Loeflund's Cream Emulsion is stated to be made from the best Bavarian mountain milk, together with malted wheat extract; no cream is removed from the milk, no cane sugar is added, and the flour is so thoroughly changed by diastase that only the soluble carbohydrates, dextrin and maltose, are left. The term emulsion is not fairly applicable; it is a thick brown paste, with a smell and taste of maltose, and does not mix uniformly with water.

TABLE CII.

Composition of Loeflund's Cream Emulsion.

Leeds' Analysis.	
Water	24·32
Soluble proteids	3·24
Insoluble proteids	4·99
Fat	15·32
Maltose and lactose	43·16
Dextrin	6·27
Ash	2·60

Composition, as stated by the makers.		
Milk Fat		6·0–7·0 per cent.
Carbohydrates	maltose lactose dextrin	33·0 to 36·0%
Nitrogen substances		7·0–8·0 per cent.

The usual method of analysis gave 7·4 per cent. fat. Leeds obtained the higher figure by diluting the emulsion, precipitating the proteids and fat, and estimating from the precipitate.

Allen and Hanbury advertise three different preparations as suitable for an infant from birth onwards. The following statements are taken from their advertisements:

No. 1. The "First Food" is for use from birth up to the age of three months. It is a dry powder made from cow's milk from which the excess of casein has been removed and the deficiency in fat, albumin, and milk sugar corrected. It is said to be sterile and to require merely the addition of hot water for use.

No. 2. The "Second Food" is for use from the age of three to six months, and is prepared by adding to the first food maltose, soluble phosphates and albuminoids derived from whole meal. It is said to contain no unconverted starch. The starch is converted into maltose and dextrin. Like the first it is sold in the form of powder and only requires the addition of hot water.

No. 3. "Malted Infant's Food" is for use after the age of six months. Its basis is fine wheaten

flour which is heated and subjected to the action of malt extract, so as to partially digest the starch, and then dried at a gentle heat. It should be prepared with fresh milk, diluted if necessary.

Numerous other foods of similar nature to one or other of the above are obtainable. Were the value of these foods great in proportion to their number, it would warrant more time being spent over their composition and the consideration of their numerous virtues, in the eyes of the manufacturers. In my experience, derived from a large out-patient department at one of the hospitals for children and from consulting practice, it is rarely necessary to recommend the addition of any one of these foods to the diet of the child. The amount of harm and the mortality due to their use far outweigh the advantages derived from them in a few cases. In nearly every child who is being fed on one of these foods, the food is taking the place of far more suitable and appropriate milk. Few mothers grasp the fact that a bulky food, which fills the stomach of the child, is not necessarily a nutritious one. In many cases the food is given because the child is constantly crying and, as its cries are almost invariably due to indigestion and not to hunger, it is only too probable that the results of the additional food will be further indigestion and gastro-intestinal trouble. In a few cases food, such as Mellin's, Horlick's, Allen and Hanbury's, Savory and Moore's, or Benger's may be given with advantage. In the early months of life a food consisting mainly of converted starch can be taken in small quantities, unless it sets up diarrhœa, but I have not found that it has any special advantage over cane sugar. If it be desired gradually to

accustom the child to the digestion of starch, there is no harm in beginning with a dextrinised food and gradually passing on to a partially dextrinised food, and finally to a pure farinaceous one. A simpler and more rational method is to give the child barley, oatmeal or rice water in small quantities and to gradually increase the amount of the starch by increasing the thickness of the preparation.

Nitrogenous Foods.—Those preparations containing meat extractives, or proteid, or the products of the pre-digestion of proteid, which are sold as proprietary foods, are briefly considered in the Appendix. They are frequently used during illness and even for very slight digestive disturbance during infancy. Their value is usually in inverse ratio to their cost, and they may be regarded as absolutely unnecessary.

It may be laid down as an axiom that no proprietary food is necessary for the bringing up of infants by hand as long as good cow's milk, cream and sugar are available. A large number of the cases of intestinal disorders in infants are due to these foods. If one does not agree another is given, until at last the mother loses heart and takes medical advice instead of relying on that of her numerous friends and her nurse. One unfortunate infant came under my care at the age of three months for wasting and intestinal trouble due to experimental feeding. It had taken no less than fourteen different proprietary foods during its short existence. The wonder was, not that it did not get fat, but that it had survived.

CHAPTER XVI.

THE DIET AFTER WEANING AND IN EARLY CHILDHOOD.

WEANING should be commenced at the end of the ninth month and completed in the course of another month. For various reasons it may be delayed, but under no conditions should a child be kept at the breast after the twelfth month. The period between the commencement of weaning and the end of the twelfth month may be spoken of as the transitional period. During this time the diet of the infant is first changed gradually from breast milk to modified cow's milk. After this change is successfully accomplished, additional carbohydrate food may be given. It is not essential to give the infant additional food at this age, and many children will progress better on a simple milk diet.

The following mixtures may be recommended for use during the transitional period:

TABLE CIII.

A Mixture for Use during the Tenth Month.

Cream . .	1–2 tablespoonfuls
Milk . . .	6–4 ,,
Barley water .	4–6 ,,
Sugar . .	1 lump

The method of weaning is detailed in chap.

viii. When the child is quite weaned it should be taking seven feeds of the above mixture, with intervals of three hours between each feed.

TABLE CIV.

A Mixture for Use during the Eleventh Month.

Cream . .	1–2 tablespoonfuls
Milk . . .	7–6 ,,
Barley water .	6 ,,
Sugar . . .	1 lump

This mixture amounts to a total of seven ounces, and may be given six times a day, with intervals of three and a half hours between each feed.

TABLE CV.

A Mixture for Use during the Twelfth Month.

Cream . .	1–2 tablespoonfuls
Milk . . .	9–8 ,,
Barley water .	6 ,,
Sugar . . .	1 lump

This mixture amounts to a total of eight ounces, and may be given five times a day, with intervals of four hours between each feed.

It is advisable to increase the amount of milk gradually, as the child gets older, and to go back to the weaker mixture if the stools indicate that the richer food is not properly digested. A diet sheet for the transitional period may be drawn up thus:

TABLE CVI.

Time Table for Feeding during the Transitional Period.

Age in Months.	9–10.	10–11.	11–12.
Intervals between feeds . .	3 hours	$3\frac{1}{2}$ hours.	4 hours
Number of feeds in 24 hours .	7	6	5
Amount of each feed . .	6 oz.	7 oz.	8 oz.
Total amount in 24 hours .	42 ,,	42 ,,	40 ,,
Feeding times . . .	5.0 A.M.	5.0 A.M.	5.0 A.M.
	8.0 ,,	8.30 ,,	9.0 ,,
	11.0 ,,	12.0 P.M.	1.0 P.M.
	2.0 P.M.	3.30 ,,	5.0 ,,
	5.0 ,,	7.0 ,,	9.0 ,,
	8.0 ,,	10.30 ,,	—
	11.0 ,,	—	—

It will be seen from the above tables that the amount of food taken in the twenty-four hours remains almost the same, but the proportion of solid constituents in it is considerably increased. Some children require more, some cannot take as much.

After having been placed on a mixture of milk, cream and barley water, there is not the least objection to adding a small quantity of one of the malted foods, such as Mellin's or Horlick's, especially if the child is at all constipated. Half a teaspoonful in the bottle, three times a day, is quite sufficient to begin with at this age. If there is a prejudice in favour of such foods the amount given may be slowly increased, and the food may then be changed to a partially malted food containing a fair proportion of starch.

If there is no special fancy or reason for giving such foods, the barley water, or oatmeal water if the child is constipated, may be slowly thickened in

The BABY CHAR

Name ....

	AGE IN DAYS.														
Weight in lbs. & ozs.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
10															
9½															
9															
8½															
8															
7½															
7															
6½															
lbs. 6															
Number of feeds.															
Amount of food in 24 hrs.															
B.O.															
Notes as to the composition of the food.															

Whiteman & Bass. Litho. London.

London, J & A Church

the First Month.

Address.

16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
																10
																9½
																9
																8½
																8
																7½
																7
																6½
																6 *lbs.*

The BABY CHAR

Name...............................

	AGE IN WEEKS.																							
Weight in lbs.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	2
21																									
20																									
19																									
18																									
17																									
16																									
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14																									
13																									
12																									
11																									
10																									
9																									
8																									
7																									
lbs. 6																									
Nº of feeds in 24 hours.																									
Total amount of food in 24 hours.																									
Notes as to the evacuations.																									
Notes as to the composition of the food.																									

Whiteman & Bass, Litho. London.

London, J & A Churchill

or the First Year.

Address ....

26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	
																											21
																											20
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																											13
																											12
																											11
																											10
																											9
																											8
																											7
																											6 *lbs.*

at Marlborough Street.

consistency. The child is thus taught to digest increasing quantities of starch. Should it be necessary to give the food in a more digestible form, the mixture may be mixed in the required proportions, a half teaspoonful of Benger's Liquor Pancreaticus added, and the whole allowed to stand in warm water for half an hour. A considerable quantity of the starch and the proteids of the milk will be thus pre-digested. Or Benger's food may be given.

In the above tables the mixtures chosen are such as can be prepared under any circumstances without any special apparatus or milk-supply. It is considerably simpler to make use of laboratory milk, containing known percentages of the different constituents, or of "Cream Milk" or Gärtner's "Fettmilch." If any one of these is employed it is only necessary to increase the amount for each feed up to from six to eight ounces according to the hunger and the digestive capacity of the child. Or mixtures prepared according to the recommendations in chap. x. may be used. None of these, however, contain any starch, and as it is advisable to begin teaching the child to digest gradually increasing quantities of starch, it is necessary to add to them some farinaceous food. A teaspoonful of barley jelly, or oatmeal jelly, may be added to every other meal, and, if well digested, the amount may be slowly increased up to a tablespoonful. Or a teaspoonful of cornflour, ground rice, or arrowroot may be given. It should be made into a thin paste with cold water, and then added to the hot milk, while stirring, and the whole well boiled. Some of the farinaceous proprietary foods are permissible at this

period, but enough has been said to show that there is no necessity for their use. Elioart's mixture may be given if a malted food is preferred. It can be prepared at home (*vide* Appendix), and the amount of conversion of the starch gradually diminished by lessening the duration of the exposure to heat.

Other foods which may be given with advantage during this period, and in the case of hand-fed infants at even an earlier age, are yolk of egg and raw meat juice. It has been previously pointed out that the necessity of boiling milk for the use of infants renders it to a certain extent deficient in anti-scorbutic power. Children brought up on suitable milk mixtures may show traces of scurvy. More commonly they are anæmic and sometimes rachitic. To remedy and guard against these affections it is advisable to administer the yolk of one fresh egg daily, divided into two halves and mixed up with the milk mixture. It can be given raw or lightly boiled and very rarely disagrees. Or the yolk of an egg and raw meat juice may be given on alternate days. The advantage of the egg over the meat juice is that it is sterile at the time the egg is broken. Meat juice is not sterile at the time it is prepared and very quickly goes bad, especially in hot weather, when it is not fit for use at the end of a couple of hours, unless it has been kept in a closed bottle surrounded by ice in a refrigerator. If heated to destroy the micro-organisms, which it contains, its digestibility and nutritive value are considerably diminished by the coagulation of the albumin. There is also a slight risk of the child acquiring a tape-worm from its use, but this risk is a very small one in this country.

Various other foods may be given at this age if for any reason, such as an attack of acute gastro-enteritis or profuse vomiting, it is deemed advisable to discontinue milk for a time. Arrowroot, barley, oatmeal or rice water may be given if a pure carbo-hydrate fluid is indicated; egg albumin water, if proteid food is thought more suitable. The preparation of the foods mentioned is described in Appendix.

Egg albumin and barley water, egg milk, custard made with egg and milk, rice milk, and whey are all available during this period.

Diet from 12–18 Months of Age.—It is not absolutely essential to add to the diet at this period. If the child is thriving on a simple milk diet and is satisfied and contented it may continue on this alone until eighteen months of age. Or it may continue on the diet of the transitional period, the amount of milk and the proportion of farinaceous food being a little increased. Usually the mother, even if the child is satisfied, is not content that the latter should keep to such a limited diet and is anxious to give it strange and deleterious compounds. Few infants are satisfied with a purely milk diet after the age of twelve months, and many will require additional food before that age. The milk may now be given undiluted or merely a little diluted. Various other articles of food may also be given. Care must be taken to avoid both underfeeding and overfeeding, to select a suitable diet adapted to the digestive powers; to give enough to maintain growth; and to keep to milk as the basis of the dietary. Such a diet is contained in the subjoined table. It is assumed that the child has already learned to digest

starchy foods in the form of barley water or jelly, or similar preparations from wheat or oats.

TABLE CVII.

Diet from the Age of 12–18 *Months.*

First meal at 6.0 to 7.0 A.M.:
- Six ounces of boiled milk, hot or cold.
- A slice of stale bread or a rusk broken up and soaked in the milk, or a slice of thin bread with dripping or butter.

Second meal at 8.30 to 9.30 A.M.; one of these daily:
- A small basin of bread and milk.
- A little fine oatmeal porridge with cream or milk.
- A basin of thick milk gruel.
- A cup of thin cocoa made with milk and a little thin bread and butter.

Third meal at 1.0 P.M.:

First course; one of the following:
- Mashed baked old potato moistened with milk, chicken or mutton broth, the red gravy of undercooked meat, or meat juice (1–3 ounces).
- Lightly boiled or poached yolk of egg mixed up with stale bread crumbs or mashed potato and gravy.
- Stale bread crumbs soaked in gravy or meat juice.

Second course; one of the following:
- A large tablespoonful of custard, tapioca, cornflour, ground rice or semolina pudding, blancmange, or junket.
- Cold boiled water or milk and water to drink.

Fourth meal at 5.0 P.M.:
- The same as the first meal, or thin cocoa with bread and butter.

Fifth meal at 9.0 P.M.:
- A large cupful of milk gruel made with rice, sago, tapioca or hominy. Or a rusk or sponge finger soaked in milk.

This list by no means exhausts the various articles of food which may be given at this age, and it is evident that the child can have a very varied and nutritious diet without being fed on foods which are likely to disagree with it. Many of these foods and the way to prepare them are given in the Appendix.

All the preparations of arrowroot, barley, oatmeal, tapioca, rice and similar farinaceous foods are available; so too bread jelly; some of the nitrogenous foods, such as the soups, broths, beef teas, meat juice and meat essence; preparations of egg; and small quantities of jellies. If the child is healthy and strong it may have a small portion of fish or meat, such as chicken or undercooked beef, for its mid-day meal. The meat should be well pounded up in a mortar or the fibrinous parts scraped away, by means of a meat scraper or strong fork, and discarded. It is not necessary to give meat at this age, but it is a good plan to begin giving it in small quantities towards the end of this period.

It is not essential to keep to the hours recommended in the above table. Breakfast may be given at 7.30 A.M.; lunch at 11 A.M.; dinner at 2 P.M.; tea at 6 P.M.; and supper at 10 P.M. The last meal should be given with cup and spoon, and not in a bottle as sometimes advised.

The next period includes the time from the eighteenth month up to the complete eruption of the milk teeth, that is, to the end of two or two and a half years of age. The diet should consist of much the same kinds of food but more meat, fish, vegetables, and fruit may be given.

TABLE CVIII.

Diet from the Age of 18–30 Months.

First meal at 6.30 to 7.30 A.M.:

A large cupful of milk with rusk, stale bread, or milk biscuit broken up and soaked in it, or some bread and butter.

Second meal at 8.30 to 9.30 A.M.; one of the following:

A basin of bread and milk.

Oatmeal porridge with milk, cream, or golden syrup.

A basin of hominy grits and milk.

Boiled milk or cocoa with bread and butter.

Boiled milk, a lightly boiled egg and bread and butter.

Third meal at 1.0 P.M. :

First course ; one of the following :

Mutton, undercooked beef, chicken, turkey, or fish, minced up finely, pounded up for the younger children in a mortar into a paste. One tablespoonful of one of these mixed up with mashed old potato or stale bread crumb and gravy. Vegetables, such as spinach, young green peas, young asparagus tips, &c.

Lightly boiled or poached egg with mashed potato or stale bread crumb and gravy.

A large cupful of broth or soup (*purée*), with mashed potato or stale bread crumb.

Second course ; one of the following :

Custard or plain milk pudding ; blancmange ; cornflour or ground rice mould ; plain sweetened jellies ; baked apple.

Fourth meal at 5.0 P.M. :

A large cupful of milk, with bread and butter, rusks, milk biscuits, or sponge fingers.

A cup of thin cocoa, made with milk, and bread and butter.

A small basin of milk gruel or bread and milk.

Fifth meal at 9.0 P.M. ; if the child wakes for it :

A cup of boiled milk, and a biscuit or piece of bread soaked in it, or a cupful of milk gruel.

Other vegetables, such as broccoli, cabbage, cauliflower or turnip-tops may be given at dinner, in addition to potatoes, but it is advisable that they should be first passed through a sieve, and in the case of the youngest infants through a hair sieve. Well mashed and well cooked turnips and carrots may also be given. The latter vegetable and potatoes may be given in the form of carrot and potato soup ; they should be passed through a hair sieve and thoroughly cooked.

For drinking, pure filtered water may be allowed. The only reliable kinds of filter are the Berkfeldt and the Pasteur-Chamberland ; if neither of these is

used the water should be both filtered and boiled. It is a good plan to teach the child to drink only at meal-times, but in hot weather a small quantity of water, barley water, or milk and water may be given between meals to relieve thirst. The water should not be iced, as it is then liable to set up gastritis. No tea, coffee, beer, ale, stout, wine or other alcoholic stimulant is permissible. It is not uncommon to find mothers giving ale and stout to infants at a very early age, even during the first month of life. Possibly a teaspoonful of light ale occasionally may not do harm and may even act as a mild bitter tonic, but it should certainly never be given, except under medical orders. Needless to say it is very rarely recommended by the physician, and considerable harm results from the mother giving it on her own responbility.

Diet after the Milk Teeth are cut.—Four meals a day are required and may be distributed as follows:

TABLE CIX.

Diet after the Age of Two and a Half Years.

Breakfast at 7.30 to 8.30 A.M. :

Either bread and milk, porridge with milk or golden syrup, or hominy grits and milk ; bread with butter, dripping, or fruit jelly ; milk or cocoa to drink.

After the age of four :

Eggs lightly boiled, poached, or scrambled ; plain omelette ; a little fat bacon or ham ; a little fish ; fresh potted meat.

Lunch at 11.0 A.M. :

A cupful of milk or broth and a slice of bread and butter, or a plain biscuit.

Dinner at 1.0 P.M., of two courses, selected from :

Vegetable purées ; minced beef, mutton, chicken, or turkey ; boiled fish ; poached egg ; mashed potatoes and pounded-up vegetables ; macaroni. Milk puddings, blancmanges, farinaceous moulds, stewed fruit, jellies,

Tea at 5.0 P.M. :

A basin of bread and milk, milk gruel, hominy and milk ; a cup of milk with bread and butter, biscuit, or bread and potted meat or fish ; fruit jellies may also be allowed.

Supper at 9.0 P.M., if required :

A cup of milk and a biscuit.

After the age of four the meat need not be minced, but care must be taken to see that the child eats slowly and masticates its food thoroughly. On no account should the child be allowed to bolt its food. With this precaution and a diet of plain food, such as recommended above, there is not much risk of the child over-eating itself. Many other similar foods can be added to the above list.

A child should not be allowed to get up hungry from its meal and, if it is made to eat slowly, may eat as much as it wants of plain food at the meal-time.

After the age of five, three meals a day are sufficient. It is not, however, advisable to limit a child strictly to only three feeds a day. A drink of milk and a biscuit or slice of bread and butter may be allowed during the middle of the morning and late at night. The metabolism of a growing child is rapid, especially in active and versatile children, and food is required to provide material both for the supply of energy and the purposes of growth.

If the child is hungry the fourth meal, luncheon, may be continued indefinitely and in the case of some children, who are delicate or growing fast, should be insisted on. Eating between meals ought not to be encouraged. Many mothers bring their children for advice on account of loss of appetite, the reason being that the child is always eating between meals.

No condiment but salt should be allowed. Highly seasoned made-up dishes and fried foods are not recommended.

It is very common for mothers to talk boastingly of the strange foods their children take with apparent impunity. No doubt many children live and grow up healthy under the most untoward conditions, but it does not follow that, because one child can digest indigestible and unsuitable foods, every child can do the same. A very large percentage of the ailments of all children, not babies only, is due to errors in diet, and there is no doubt that every child will grow up stronger and more healthy on a simple nutritious diet, such as is recommended above, than on the rich fancy dishes and indigestible foods often given.

I cannot speak too strongly against the custom of giving children tastes of the various foods partaken of by the parents, when the children are allowed to eat or sit at the same table. A child is contented with plain food if it has not learnt the taste of other food. Sunday mid-day dinner is a great source of evil in this respect. The child is allowed to come down to dessert and is given tastes of fruit, fresh and candied, cakes, almonds, nuts, and even wine. Every child is anxious to handle any article that is new to it, and the first method it adopts to find out what the article is made of is to put it in its mouth. Hence it clamours for what it sees on the table and the parents to please it, or to stop it whining, give it all it asks for. An invariable practice should be made of letting the child have its meals separately in the nursery with a competent person to teach it manners, and of not giving it anything from the table or between its regular meals. The only excep-

tion that may be permitted at the Sunday dinner-time is to have on the table some plain milk biscuits or sponge fingers. The child will eat these with contentment and without injury if it is really hungry. If it is not hungry it is better without extra food.

The pulp of grapes with the stones carefully removed, bananas, and baked apples, may be given in small quantities after the age of one year. Prunes, skinned and stewed, are permissible after two; peaches, nectarines, raspberries, and other fruits not containing seeds or stones, after five years. When fruit is allowed it must be ripe, but not over-ripe; in large towns it is often too ripe and gives rise to diarrhœa. When given, and the same rule applies to the administration of any fresh article of food, only a small quantity must be allowed.

Certain foods must be avoided until the child gets older and its digestive capacity greater. Pork and foods made from it are especially liable to disagree and not uncommonly give rise to attacks of vomiting and diarrhœa, and in some cases to convulsions. A child of one year of age came under my care for fits induced by feeding it on bacon, the bacon being given in pieces about half an inch long and a quarter of an inch thick. In spite of all that could be done the child died during a second convulsion a few hours later. Other cases, of similar attacks I can call to mind, have been induced by peas, bubble and squeak, steak and onions, sausages, raw apples, nuts, &c.

Apples, unless well baked, pears, gooseberries, pine-apple, and nuts are not allowable. Fried fish is not as good as boiled fish and should not be given before

the age of three. Tripe is rarely so well cooked as to be suitable, and as usually cooked is very indigestible. Cheese must not be permitted before five years of age, and should then not be given if decayed. High game, such as grouse or venison, is not allowable. Rabbits are somewhat indigestible and so is veal; both may be given after the age of three if well boiled, minced and pounded.

Stimulants must not be given except under medical advice and supervision. If the child is delicate and growing rapidly, or if recovering from an acute or debilitating illness, some mild stimulant may be desirable. It is a mistake to continue with it for a long period and should not be given for more than a month, except on advice. For very young infants a few drops of brandy added to the milk is a suitable stimulant. Older children may take a small glass, five ounces, of light ale or stout with their dinner; or a little Tarragona port, one tablespoonful twice or thrice daily; or sweet still hock or burgundy in similar doses; or the egg-and-brandy mixture prepared as in the Appendix.

CHAPTER XVII.

WET NURSES.—THE TRANSMISSION OF DISEASE BY BREAST MILK.

SEEING it is an accepted fact that human milk is the best food for an infant under nine months of age, it follows that if for any reason, physiological, pathological, or psychical, the mother is unable to suckle her infant, the best substitute is the milk of some other woman. Human milk has been shown to be very variable in composition, and it does not always happen that the milk of a nurse chosen haphazard will suit the particular infant for whom it is required, especially if the infant is a delicate one. In some cases a wet nurse or foster-mother is the means of saving the child's life; the continuance of the natural mode of feeding being at times of the utmost importance.

A good nurse is far superior to artificial feeding, but if only a poor nurse is available and the conditions are favourable for artificial feeding, the latter method of rearing should be preferred. In former days a foster-mother was the only substitute for the mother we could rationally recommend. In the present day, more especially in our own country, the employment of a wet nurse is rarely advised, much less insisted on. The knowledge of the compo-

sition of human milk, of the capacity of the child's stomach at different ages, of the composition of cow's milk, and the methods for preparing and administering it, has enabled us to provide for the child a diet, regular in quantity and quality, and suitable to its requirements and digestive capacity.

In other countries, notably France and Russia, wet nurses are commonly employed and are even provided by the State in the foundling hospitals.

Many objections can be urged against this means of bringing up the babe. A wet nurse is difficult to obtain and is expensive. Occasionally I have been compelled to send the parents to Paris to procure one. A woman with unknown temper and morals, whose past life may have been positively intemperate and dissolute, is introduced into the house and to a peculiar intimacy. Wet nurses are necessarily drawn from a class of life morally and physically much inferior to those of the parents of the child. Generally they are the mothers of illegitimate children, but this is not of much importance, unless the woman has had so many as to indicate the mode of life she has been leading. Such a mode of life may lead to syphilitic infection or tuberculosis. Trouble may arise from the liability of the nurse to think that, because of the dependence of the child on her for its food, the whole arrangements of the house must depend on her pleasure and convenience. At any time, having only a pecuniary interest in the welfare of the child, she may desert it or threaten to do so with a view of securing a rise of wages. Unaccustomed, too, to a liberal diet and perhaps having been insufficiently fed before being engaged she is liable to eat and

drink too much, and to take insufficient exercise, with the result that her milk becomes altered in quality and unsuitable to the digestion of the child. In the country and in small towns it is sometimes possible to obtain as wet nurse a woman whose character and antecedents are well known. It may be advisable in such cases to let the child be put to nurse with the foster-mother at her own home, if she is sufficiently trustworthy. Occasionally a wet nurse is absolutely essential, rarely though this may happen, so it is necessary to consider what kind of woman should be chosen, and the difficulties which arise in the selection and in carrying out the arrangements and management successfully.

A wet nurse is indicated if the child is being breast-fed and is steadily losing weight, provided that there are objections to artificial feeding. During hot weather in towns it may be thought unwise to run the risk of feeding a delicate infant on any form of cow's milk. If the babe's digestion is upset from any cause we can fall back upon a wet nurse, more especially in those cases where artificial feeding and numerous proprietary foods have been tried. Such infants usually appear in the consulting-room at two to three months of age, and if proper mixtures of cow's milk fail, must be fed on the breast. It is, however, rare for such infants not to do well on milk mixtures.

Practically all that has been written in a former chapter concerning the perfect mother applies with equal force to the wet nurse. The family history and the past history should contain no evidence of any tuberculous disease, insanity, epilepsy, or other neurosis. Even in an apparently healthy woman

the strain of lactation may lead to the development of one or other of these diseases, if there be already an existing predisposition.

Choose a multipara, or at any rate a woman who has had two children, and consequently some experience in nursing, between twenty-five and thirty-five years of age. Sometimes preference is given to a primipara between twenty and thirty years of age on the ground that a young woman is more likely to be healthy and that the milk of a primipara contains more fat and proteid. The latter reason is a bad one. See that the first child was successfully reared and that it is not rachitic and is in other respects perfectly healthy. If either child is dead ascertain what it died from, making special inquiries with a view to finding out whether its death was due to some syphilitic taint. If the second child is living examine the buttocks and angles of the mouth in order if possible to exclude hereditary syphilis. It is advisable for this reason that the child should be about three months old at least. If the child is wasted or shows any sign of disease it implies that the mother's milk is unsuitable, that there is some hereditary taint, or that the mother is lacking in experience or neglects her own child. Needless to say, if she is neglectful of her own child she is not likely to bestow proper care and attention on her foster-child.

The milk of a wet nurse whose own child is over one month and under six months of age will generally agree with a new-born infant. It is not at all necessary that the nurse's child should be exactly the same age as the one for whom she is required. It has been shown in previous chapters that the

milk alters very little, if at all, in composition as lactation advances. It is essential that the child should be strong and vigorous and at least three weeks old. This implies that the mother's milk is sufficient in quality and quantity, and that there is probably no syphilitic taint. It must not be forgotten that sometimes congenital syphilis is latent and is not evident at birth or even a few months later. Even with the most careful inspection of both the mother and child the risk cannot absolutely be excluded, and the presence of a perfectly healthy first child does not prove that the woman has not contracted the disease since its birth. The child may even be apparently perfectly healthy and well nourished, although specific signs develop shortly afterwards. Constitutional syphilis is by no means uncommon among these women and its symptoms are often very slight or absent, or may be concealed. The infection may pass to the child from excoriations or fissures of the nipples.

Physical Condition of the Nurse.—She should be strong and robust, well nourished but not very fat, and free from all evidence of disease. Slight anæmia is not of much importance as it can be remedied by appropriate treatment. Chronic dyspepsia is rather an objection, being liable to impair the general health and lead to alterations in the quality of the milk. Menstruation, if regular and normal in amount, may be disregarded. Pregnancy renders the woman unsuitable. Evidence of old rickets is a slight objection on account of the tendency of rickets to run to a certain extent in families. In connection with this it is worthy of mention that rachitic women are liable to lose their

children in labour and consequently to be available as wet nurses.

Physical Examination.—This must never be omitted under any circumstances. Note the general appearances of health: sound teeth, clean tongue, clear complexion, healthy skin, general aspect of cleanliness. Examine the throat and hair and note whether the glands are enlarged. See that the breasts are of good size and not too fat, containing a due amount of glandular tissue. Note the presence of any hyperæsthesia or mastitis. The nipples should be well developed, free from erosions or fissures, and the milk should flow easily.

The supply of milk should be estimated:

1. By the weight of the mother's child before and after nursing. If possible the child should be weighed on more than one occasion, and the mother visited unexpectedly for the purpose.

2. By the diminution in the size of the breast when nursing. If there is much fat and little glandular tissue, the diminution will be small.

3. By the subsequent increase in size in two to three hours' time. If attention be not paid to these points, the nurse, if dishonest, may withdraw the breast from her child many hours before the time arranged for the examination, in order to have a good supply; in the same way as cows are often prepared for market. This and the last rule do not invariably hold good. In some women secretory activity is only stimulated by nursing, and there is comparatively very little change in the size of the breast in the intervening period. The child may obtain a sufficient supply of milk from such breasts.

4. By the satisfied manner of the child while

suckling, and in the way it drops off to sleep when its stomach is full.

Examination of the milk, microscopical and chemical, is rarely necessary, and may be dispensed with if the nurse's child is healthy and takes the breast in a satisfactory manner. If it has been found by analysis of the milk of the mother of the child, for whom the nurse is required, what percentage of proteid can be digested by it with advantage, then it is of great value to have a chemical analysis of the nurse's milk. Usually it is in cases where the child's mother has no milk, or has died during her confinement, that a nurse is wanted, and we cannot obtain such data to go upon. A fair estimate of the quality of the milk can be obtained by Holt's method, taking the specific gravity and estimating the percentage of cream which rises to the surface. For microscopical examination refer to chap. vi.

An examination of the genitals must be made, and care taken not to overlook gonorrhœal disease, chancres or scars of old chancres, and other affections which may cause deterioration of the general health. The presence of syphilis or the evidence of past syphilis is of importance apart from the danger of transmission of the disease. Mothers, thus affected, do not usually secrete good milk though often they are able to rear their own infants successfully.

Moral Fitness.—The nurse should have a placid, easy-going disposition, and be truthful, affectionate, fond of children, good-natured, and not liable to outbreaks of temper. Emotional women do not make good nurses, the secretion and the composition

of the milk being under the influence of the nervous system. She should be cheerful and active, temperate in food and drink, and of average mental capacity. If unmarried, the fact that it is a first child is in her favour ; a second implying rather that she is immoral. By preference, she should be married. She must have a due sense of responsibility, and be prepared to undertake the duties for as long as required, and to sacrifice entirely her own child for that of her employer.

General Management.—As far as possible, under the altered conditions of her environment she must live her ordinary mode of life. Proper food, exercise, and general hygiene are essential.

The diet should be generous, nutritious and easily assimilable. Remember that the woman has probably been reduced in circumstances, otherwise she would not be willing to sacrifice her own child for a money reward, and that consequently her former diet may have been plain and insufficient. A sudden change to practically an unlimited diet will lead to over-eating, the production of too rich milk, and probably digestive disturbance in both nurse and child. An excess of meat should be guarded against, if the customary exercise cannot be taken. All foods and drinks causing flatulence must be avoided, such as strong tea, pork, pastry, pickles, onions, &c. A moderate amount of malt liquor, ale or porter, may be allowed, but not more than a pint a day. As a rule half a pint is sufficient, and it is still better if even this amount be not allowed. An increased amount of nutritious liquids, such as cocoa, milk, milk gruel and meat broths, may be given to increase the flow of milk, if insufficient.

Beetroot is also recommended. No nurse should be engaged who has not a good milk-supply.

Plain simple nutritious food is really all that is necessary, and there is a much greater danger of over-feeding than under-feeding a wet nurse. The same rules hold good for the wet nurse as for the mother during the period of lactation.

Bathing.—Personal cleanliness is of great importance and is not always approved of by the nurse. A tepid sponge bath should be taken daily in the morning, and the breast and nipples carefully washed both before and after suckling. If the milk-supply is so abundant as to trickle away in the intervals between the nursings, a pad of antiseptic cotton-wool must be worn over the breast and frequently renewed, especially in hot weather.

Exercise.—The nurse should take walking exercise daily and the more she eats, particularly of meat, the more exercise should she take. If the weather is warm it is better for both nurse and child, unless the latter is very delicate, to be as much as possible out of doors. If unable to get out on account of the weather the nurse should be set some indoor work requiring active movement and not be allowed to eat, suckle and sleep all day long as she sometimes does.

Apartments.—Make the nurse entirely responsible for the cleanliness of the apartments as well as of the child. This implies a moderate amount of useful necessary work. The rooms should be well ventilated and not overheated; two are essential, a night and a day nursery. On no account should the nurse allow the child to sleep in her bed, it must

be kept in a crib by the side and placed there after being fed.

Cautions.—If the nurse's child is alive the employer should see that it is properly cared for and provided for. Needless to say, if the nurse is anxious and worried about her own child her supply of milk is liable to deteriorate in quantity or quality. A certain moral obligation lies on the employer not to allow the child to suffer whose mother he pays to deny it its natural food-supply. The mortality among the children of wet nurses is enormous. They usually die under the age of three months and, for their sake, no wet nurse should be engaged whose child has not passed that age.

If the nurse's own child be alive the nurse must not be allowed to live at home and come periodically to suckle her employer's child. Under such circumstances she is almost certain to try and suckle both. Apart from such temptation, the conditions of her home life are likely to be unsuitable, possibly unsanitary, and she may be the medium for conveyance of infectious disease. Besides this there is lost all control over the habits of life, diet, drink, &c.

Observation must be kept upon both nurse and child to see that she does not attempt to supplement a deficient milk-supply by artificial means, such as giving cow's milk, and that she does not soothe an infant, irritable from indigestion or insufficient food, by means of opiates.

Transmission of Disease, &c.—The popular notion that the mental and moral qualities of the nurse can be transmitted to the suckling through the medium of the breast-milk is absolutely without foundation and need not be considered.

On the other hand many diseases can be transmitted by the nurse, either through the milk or by other channels of infection, more especially syphilis, tuberculosis, and pyæmic affections.

Stiegenberger recorded in 1890 the case of a child aged five months with well-marked tuberculous caseating glands. The parents were healthy, but the child had been nursed for a month by a woman with active pulmonary phthisis.

The transmission of syphilis by the nurse is only too well known to require comment. Before blaming the nurse it must be remembered that the child may have been exposed to other sources of infection, and that the inherited form of the disease may be late in its manifestations. It is also, in the opinion of most physicians, possible for the congenitally syphilitic infant to transmit its disease to the nurse.

Colles' teaching about the infectivity of this disease is not universally accepted. According to this authority a woman may bear a syphilitic infant and suckle it without contracting the disease herself, while another woman, nursing the same child, can contract the disease. The cases brought forward as illustrative of this law might be explained on the supposition that they were cases of acquired syphilis and not due to the inherited taint. There is no recent clinical evidence to show that a wet nurse has acquired the infection from a congenitally infected child. The evidence rather tends to an opposite conclusion. The view of R. W. Parker that many of the lesions found in congenital syphilis are "inherited from syphilis," without being truly syphilitic in the ordinary sense of the term, is a very likely one.

Günzburg, physician to the Foundling Hospital at Moscow, made careful observations on the wet nurses employed in the syphilitic ward. Out of 31 healthy women who suckled 120 of these children for a total period of $395\frac{1}{2}$ months not one was infected. The shortest period a nurse was engaged in this occupation was six months, the longest two years. Henoch has never come across a wet nurse infected by this means. My own experience has led me to the conclusion that congenital syphilis is rarely, if ever, contagious. Many illegitimate infants are thus affected and are put out to nurse, yet I have never come across a case of the nurse acquiring the infection under such conditions, even from the most severe cases. Two other arguments may be urged against the view that this disease is the same as true syphilis. A child thus affected is liable to be attacked by acquired syphilis when exposed to the contagion and, further, does not propagate the disease.

On the other hand Cory, after several experiments, succeeded in inoculating himself with the disease from a bad case of the inherited form. Cases of vaccination syphilis are not unknown. They are however remarkably rare, considering the prevalence of congenital syphilis, if this disease is as contagious as generally supposed.

We are justified in regarding these cases as non-contagious except, perhaps, in rare cases of very virulent forms of the inherited disease. If these views are not accepted a syphilitic child must under no circumstances be put to nurse, for it becomes morally, if not legally, criminal to subject a woman to the risk of catching this disease. No matter

how great the money reward or the importance of maintaining the child's life, no medical man would be justified in giving his sanction to such a proceeding. It is a doubtful point whether a medical man, believing in the contagiousness of the affection, and knowing that the parents are procuring a wet nurse for a syphilitic child, without his advice or opinion being asked, would be justified in interfering. It would be a gross breach of professional confidence to inform the nurse of the risk she ran, and might expose the doctor to legal proceedings. Probably it might be sufficient to warn the parents that they will be liable to an action for damages, and consequent publication of their family misfortune, if the nurse becomes infected.

If the infant is handed to a wet nurse as soon as it is born, the risk must inevitably be run, especially if it is a first-born child without any sign of the disease. A history of previous miscarriages or of still-born children might be regarded as a contra-indication to the employment of a wet nurse, unless the cause lies in some pelvic trouble or deformity.

Whether immunity can be acquired through the medium of the milk or not, there is not sufficient evidence to show. Could immunity be thus obtained, we might, for instance, diminish the liability of a child of tuberculous parents to develop the disease by feeding it from the breast of a woman previously rendered immune. There is a considerable amount of evidence in favour of the view of inherited immunity in tuberculosis. Science has not yet advanced far enough in this direction. In the case of mice Erlich has shown that immunity

against tetanus can be acquired in a very brief space of time through the mother's milk. He used serum from an immune horse to give immunity to the mother when her young were seventeen days old. One of the sucklings was immune at the end of twenty-four hours.

CHAPTER XVIII.

THE FEEDING AND MANAGEMENT OF PREMATURE INFANTS.—THE METHODS OF GAVAGE AND LAVAGE.

THIS group of cases includes all infants born before the end of the two hundred and eighty days which represent the average duration of intra-uterine life. The premature infant differs from a fœtus in being viable, that is, in being able to maintain an independent existence. If the infant is only a week or two premature no special care or feeding is necessary, provided it is well developed and weighs over six pounds. It is the infants born at an earlier period of gestation that are so difficult to rear, and this difficulty increases rapidly in proportion to the diminution in maturity. It is always very doubtful whether an infant can be reared when born before the twenty-eighth week of intra-uterine life. Villemin, however, reared successfully an infant delivered at five and one-half months, or on the most liberal computation at six months; it weighed less than two pounds at birth. Charpentier reared an infant which weighed under two pounds and five ounces at birth. The use of the incubator, the prevention of sepsis, and proper methods of feeding,

have increased the chance of living very largely. In estimating the chance of life of such an infant it must be remembered that the degree of development depends, to a large extent, on the health and surroundings of the mother during pregnancy, and, to a certain extent, on inherited tendencies; and that the viability of the child depends upon the degree of development rather than on the actual age, even if this could be accurately ascertained. The premature infant of a healthy, well-developed woman will live when that of a delicate, small, tuberculous, or syphilitic woman would not have the smallest chance. No matter at what period the infant is born, or what the stage of development, as long as it breathes an attempt must be made to preserve its life.

A premature infant is under weight, breathes and eats imperfectly, has imperfectly formed organs, and ill-developed functions. The cry is feeble, perhaps absent. The muscles are weak, and in the earlier cases may be absolutely inert, the child lying quite motionless and in a kind of torpor; it may not even be able to suck by reason of the muscular debility. The skin is soft and delicate, and so transparent that the superficial blood-vessels can often be seen; it is bright red in colour, and there is little subcutaneous fat. After seven months intra-uterine life the skin loses its bright red colour. Lanugo is plentiful, and some hair may be present on the scalp. The nails are thin and do not project beyond the finger tips. Nearly all the ossific nuclei are present; those of the lower end of the femur and upper end of the tibia being usually absent. The kidneys are lobulated. The grey and white matter

of the brain are not differentiated. The head is large, the face looks small and wizened, and the belly protuberant. The digestion of fat and proteid is imperfectly developed. Absorption and assimilation are defective. In order to rear such an infant, it is necessary to maintain the bodily temperature, to provide it with sufficient digestible food, and to protect it from exposure and shocks.

In treating these cases the daily weighing is of essential importance, as it is the only available indication of the progress the child is making. Until the daily increase is regular and progressive we cannot be certain that the treatment is satisfactory and that the child may live. The loss of weight during the first three days is not more marked than in infants at term, but recovery takes longer, on an average thirty days. The loss is, therefore, more serious; and it is found that the mortality is greatest during the period of loss or of stationary weight. The initial loss may bear a much higher percentage ratio to the total weight than in the full-time child, because of the immaturity of the digestive and assimilative functions. A child who attains to its birth-weight in two to three weeks has done very well. One of twins, recently seen in consultation on the day of birth, weighed 3 lbs. 9 oz. On the eighth day he weighed one ounce less. He then gained steadily an ounce a day, and at the age of seven weeks weighed 6 lbs. 4 oz., showing a gain of 43 oz. in 42 days.

The weight of premature infants at the same age varies to the same extent as the weight of infants at term, and the daily increase should bear a rough proportion to the original weight, being greater in

the heavier infants. According to Hecker and Lusk, the average weight at different ages is:

Age.	Weight.	
24 weeks . . .	690 grammes	(23 oz.)
28 ,, . . .	1170 ,,	(39 oz.)
32 ,, . . .	1560 ,,	(52 oz.)
36 ,, . . .	1920 ,,	(64 oz.)
38 ,, . . .	2310 ,,	(77 oz.)

Calculating from these figures, we find that the premature infant should gain daily, in order to maintain the same rate of development as *in utero*, from 0·75 to 1·0 per cent. of its weight; taking the higher figure, this amounts to 11·7 to 23·1 grammes (3 to 6 drachms).

Potel obtained the following valuable results from an inquiry into the circumstances of 350 premature infants. He found the average weight at birth was higher than that given by Hecker and Lusk.

Age.	Weight.
6½ months . .	1400 grammes
7 ,, . .	1700 ,,
7½ ,, . .	1900 ,,
8 ,, . .	2150 ,,

The mortality rapidly diminished with the increase in the period of gestation, thus:

At				Percentage mortality.	Average daily gain in weight.
6½ months .	11	survived out of	56 ...	80·4 ...	9·4 grammes
7 ,, .	55	,, ,,	131 ...	58·1 ...	11·5 ,,
7½ ,, .	36	,, ,,	53 ...	31·0 ...	13·8 ,,
8 ,, .	71	,, ,,	110 ...	35·5 ...	22·8 ,,

Out of the total of 350, no less than 173 survived, very nearly 50 per cent.

The absence of gain in weight indicates some

failure in the mode of treatment. Should there be a decided loss not accounted for by the discharges, it is an indication that the infant is in a critical condition.

Unfortunately weighing necessitates a certain amount of handling. All handling of these infants is to be avoided as far as possible and, when essential, must be carried out with the greatest of care.

The amount of food to be given for a feed depends on the gastric capacity, and this again upon the size of the child. As in the case of infants born at term it may be estimated as equal to one per cent. of the body weight. This method is by no means reliable, but it is the only one available. The size of the stomach varies in different infants of the same weight, just as it does in full-time children.

The composition of the food must be the same as that for ordinary infants, but the different solid constituents must be given in smaller proportions, for the digestive functions are not developed to the same extent as in the child at term. For this reason it is probable that an artificial mixture will be more easily digested than mother's milk, seeing that the latter is more likely to be richer in solids, especially proteids, at such a time. Often the flow of milk has not begun to be established. Breast-feeding is often recommended. A wet nurse who has been confined at least a month previously is to be preferred to the mother, for in the latter the colostral character of the milk is very liable to upset the child. In one instance, under my observation, the mother had attempted to nurse her $7\frac{1}{2}$-months child. I saw the child on the fifth day. The milk had disagreed and he had lost 12 ounces in weight, having weighed

4 lbs. 11 oz. at birth. He was put on weak condensed milk, but died suddenly next day. The case illustrates also the serious import of rapid loss in weight. Other advantages in favour of artificial feeding are that less handling is required than for breast-feeding, and the composition of the food can be regulated more accurately in accordance with the requirements of the child. Some infants are so feeble and ill-developed that they cannot suck even from the bottle, much less from the breast, and other methods of feeding have to be devised. At first from one-half to one drachm of a 5 per cent. solution of milk-sugar may be given hourly. In one to two days add to each feed a similar quantity of the breast-milk of a wet-nurse, and gradually increase it if it agrees with the child. Should this fail, artificial mixtures must be tried. For this the advantages of laboratory mixtures are apparently great. The food is supplied devoid of micro-organisms, the percentages of the different constituents can be reduced and regulated, and a food of constant quality is obtained.

Rotch recommends the following prescriptions:

TABLE CX.

Infant Born at the 28th to the 36th Week.

Proteid	Casein	0·25	0·50 per cent.
	Albumin	0·25	
Fat			1·00 "
Sugar			3·00 "

24 meals, each of 4 c.c. (1 drachm). Heat to 75° C. (167° F.)

If the infant is not satisfied, or if unusually large for its age, or if over twenty-nine weeks, change the prescription in a few days to:

TABLE CXI.

Proteid	Casein . 0·25 Albumin . 0·25	. 0·50	per cent.
Fat .		. 1·50	"
Sugar		. 4·00	"

24 meals, each 8 c.c. (2 drachms). Heat to 75° C.

If the infant is over thirty-two weeks, alter in a few days to:

TABLE CXII.

Proteid	Casein . 0·25 Albumin . 0·50	. 0·75	per cent.
Fat .		. 1·50	"
Sugar		. 5·00	"

23 meals, each 12 c.c. (3 drachms). Heat to 75° C.

If the infant is over thirty-six weeks the milk should be increased in forty-eight hours to:

TABLE CXIII.

Proteid	Casein . 0·25 Albumin . 0·75	. 1·00	per cent.
Fat .		. 2·00	"
Sugar		. 5·50	"

24 meals, each 16 c.c. (4 drachms). Heat to 75° C.

On reference to chap. x. it will be seen that mixtures, somewhat similar in composition to the above, can be prepared by mixing suitable quantities of cream, water, and milk sugar, and milk if necessary. If the infant cannot digest these mixtures an attempt must be made to rear it on peptonised milk, condensed milk, or a mixture made from egg-albumin water, cream and sugar. Raw meat juice must also be given.

Laboratory mixtures have not in my experience proved very satisfactory. On the whole, I have had the best results with weak peptonised milk. For instance, I saw a somewhat premature baby on the

thirteenth day. She weighed 4 lbs. 8 oz., having lost 8 oz. since birth, and in fact since the eighth day. She had been breast-fed for a week, next put on humanised milk, and then on a weak percentage laboratory mixture. On peptonised milk she gained 16 oz. in two weeks and made good progress subsequently. In another, more serious instance, a similar result was noted. A twin child, weighing 2 lbs. 14 oz. on the ninth day, was taking a laboratory mixture and partially kept in an incubator. Continuing the same method of feeding, and keeping the child entirely in the incubator, he remained practically stationary for three weeks. He then slowly improved, but when put on peptonised milk, at the age of two months, gained weight much more rapidly.

It is better to feed these infants every hour with small quantities than with larger quantities less frequently. In the latter case there is risk of causing dilatation of the stomach and gastro-enteric trouble. If the child is not getting sufficient food it will indicate its hunger by feeble continuous cries. Sleeping quietly between the feeds shows that it is satisfied, except in the case of a very small ill-developed infant, whose lethargy may be due to debility and inanition and requires active treatment.

If the infant is progressing well and gaining weight the length of the intervals between the feeds may be gradually increased until, by the time it arrives at term, it may be fed as an ordinary baby.

Should the infant be too feeble to suck from a suitable feeding-bottle, it may be fed by the following apparatus. A glass cylinder, graduated in cubic centimetres or half-drachms, with a sloping end to

which an ordinary nipple or teat is fitted; the other end is larger, and is covered by an india-rubber ball which acts as an air-reservoir. The food is warmed and poured into the larger end, the rubber ball is fixed on, the teat is put in the child's mouth, and the ball compressed slowly, forcing the food into the mouth. This method is especially useful in the case of very weak infants and of those brought up in an incubator. It does away with the necessity for handling and moving the baby.

In some cases the child does not appear able to swallow the food, even when it is gently and slowly forced into the back of the throat by this method, and it is necessary to feed the child by means of a tube passed into the stomach, a method sometimes spoken of as "gavage." This is much more trouble and not so easily managed by the nurse, and causes more exhaustion to the child; it will be referred to presently.

The Maintenance of the Animal Heat.—This is of the utmost importance, and depends on regulating the production of heat; in other words, the administration of a sufficiently heat-producing food in sufficient amount at proper intervals, and the prevention of too great or too rapid loss of heat. Seeing that the main source of loss of heat is by the skin, by evaporation, radiation and conduction, and that the smaller the size of the animal the greater is the proportion of the area of skin to the weight of the body and the greater the loss of temperature through this channel, it is evident that we must take special care to guard against loss of heat from the skin. For this purpose two methods are commonly used. The older, more common, and more easily

applicable method is to wrap the child in layers of cotton-wool round the body and limbs, under the ordinary clothing, and a thick fold of the same round the head. Or the child may be wrapped in cotton-wool only. The child is kept in a cradle covered with blankets and two or three hot-water bottles put under the blankets. All changes of clothing are made before a good fire. The room temperature is maintained at 90° F. The objections to this method are that the frequent changing of the napkins exposes the infant to considerable risk, the temperature of the basket or cradle cannot be accurately gauged or regulated, and the temperature of the room is very trying to the nurse who has to live in it.

The second method consists in the use of a "Hatching Cradle" or "Incubator." A more accurate term is the one used by Rotch—viz., a *brooder*, seeing that the infant is already hatched, though prematurely. Such an apparatus should be attached to every maternity home or hospital. The expense prevents its use in the ordinary middle-class household. The first satisfactory incubator was made by Denuce of Bordeaux in 1857. Credé also devised one. The best known one is that of Tarnier, of which a good description is given in *Sajous's Annual* for 1888. It was improved by Auvard. It consists of a wooden box, 65 centimetres long, 50 high, and 36 wide, with sides 25 millimetres thick and a glass top. At a distance of 15 cm. from the bottom is a partial partition for the child to lie upon and under this a space for hot bottles. At the side is a sliding door for admission. There are an inlet and an outlet for air, a sponge for moisture, and a thermometer.

TABLE CXIV.

Statistics from the Maternité (Paris), to illustrate the Value of the Hatching Cradle.

Weight of Child.	Number.	Lived.	Died.	Mortality.
1000–1500 grms.	40	12	28	70·0 per cent.
1501–2000 grms.	131	96	35	26·7 ,,
2001–2500 grms.	112	101	11	9·8 ,,
Totals	283	209	74	26·0: average mortality; 66·0: average mortality before use

TABLE CXV.

Percentages of Premature Infants reared in the Incubator.

Age at birth.	Charles.	Tarnier.	Voorhees.*	Voorhees.†
6 months	10	16	—	—
6½ ,,	20	36	22	66
7 ,,	40	49	41	71
7½ ,,	75	77	75	89
8 ,,	—	88	70	91

* Weight 2 lbs. 7 oz. to 5 lbs. 9 oz.

† Omitting those who died in a few hours.

Rotch describes an incubator devised by Worcester of Massachusetts. It closely resembles Tarnier's, being made of wood, but rather larger, and having a glass lid which can be raised for admission. The air outlet is provided with an anemometer to indicate that ventilation is being efficiently carried on. The bottom of the box contains a boiler to provide the necessary heat, and above this a bed-shelf, on which the child's bed is placed. A thermometer is attached to the lid of the box to show the temperature of

the contained air, and another is attached to the water apparatus to indicate the temperature of the water.

The objection to both these incubators is that they are made of wood, and consequently difficult to clean and disinfect. They are still more difficult to deodorise, and for this reason Rotch has devised an incubator on similar principles but made of copper and on wheels, for the purpose of moving it about readily from place to place. In it the infant can be weighed without being handled. It is a very elaborate structure.

Lion of Nice in 1891 devised a very good one, but it is expensive. A useful one can be bought or hired in London from Hearsom, of Regent Street.

Whatever method is used, frequent observations are necessary to ensure a suitable temperature being maintained and to prevent it getting too high. Keep the temperature at 90° F., or at 95° F. if the child is very premature. Gradually reduce it as the child gets older. Lower it, too, if the child's temperature rises or if sweating is induced.

Another great source of loss of heat is by the lungs in warming the inspired air. This is minimised by the use of the incubator or, if this is not available, by maintaining the temperature of the room at a high level. The incubator must be well ventilated and its air-supply pure. It must be kept thoroughly clean. It must not be exposed to the direct rays of the sun or the temperature will rise unduly high.

It must be remembered that it is of even greater importance to provide means for the internal production of heat than to check loss.

Washing and Clothing.—No more washing should be allowed than is enough for ordinary cleanliness; the importance of handling a premature infant as little as possible must be strongly insisted upon. It should not even be washed at birth if very small. Similarly it must not be dressed in the way that full-time infants are, especially if it is kept in an incubator, but should be wrapped up in layers of absorbent cotton-wool, which may be changed morning and evening. A separate piece should be used instead of a napkin and can be easily changed. If this is used, the child will be kept dry and clean without the necessity of washing. Drying powders may be used in moderation, if required; or the child may be rubbed all over with warm oil. Washing is quite unnecessary, and in some cases had better be omitted entirely until the child is gaining weight steadily, even for as long as a couple of months.

By these measures, and by feeding the child with the apparatus described above, the child may be kept in the incubator for days without being handled, except once daily for the purpose of weighing. The weighing process should be carried out in the morning when the wool is changed; the infant must be weighed in the wool and then removed to the clean wool, also weighed, and the dirty wool weighed before being burnt. From these results the weight of the child can be calculated, and also a rough estimate made of the amount of excreta passed. The latter estimate lacks accuracy on account of the evaporation of the liquid constituents.

General Directions.—The essential points in the management are to maintain the temperature

of the child, to give it a suitable diet, to prevent exhaustion, and to avoid infection of the alimentary or respiratory tract. In the latter tract the nose is very liable to become infected. Exposure to light and noise are to be avoided in the case of these young infants, and they must be gradually accustomed to light as they develop. For the sake of the purity of the atmosphere the admission of the direct rays of the sun into the room is an advantage, but the child should be kept covered up or screened off from it. The glass of the incubator can be covered with a black cloth. Every case requires constant, careful and intelligent attention. The temperature of the incubator, the amount of food taken and the character of the motions must be carefully noted. If the child cries it must be decided from the nature of the cry, the presence or absence of colic, and the character of the motions, whether the cry is due to hunger from an insufficient amount of food or to colic from food too rich in proteid. The respirations and the temperature of the child must be taken and recorded. A marked fall in temperature is a bad omen, and may indicate that the food-supply is deficient, or that something is wrong with the apparatus of the incubator: so, too, coldness of the hands and feet and any marked increase in the frequency of the respirations. If the temperature keeps continuously low it indicates low vitality. It is often irregular from lack of control of the heat-regulating mechanism. A sharp rise may indicate septic infection, gastro-intestinal conditions, or too high a temperature in the incubator. Beyond paying attention to the above points we have no remedial measures available except two: namely, the addition

of brandy in doses of two to five drops with every feed or every other feed, and the addition of oxygen gas to the air in the incubator. The latter is indicated if any cyanosis arises.

Prognosis.—Few born before the twenty-ninth week are saved. The prognosis must always be guarded, even when the child is gaining weight, because of the liability to sudden death. Rapid loss of weight, with overlapping cranial sutures, is a very bad sign. Continued slow loss of weight and a subnormal temperature are unsatisfactory features.

Respiration is imperfect, for the lungs are not fully developed, and there is a great tendency to atelectasis and hypostatic congestion of the lungs. The chest-wall possesses little resistance and is liable to sink in on inspiration. Respiration is usually irregular and may assume the Cheyne-Stokes type. Attacks of cyanosis are the commonest cause of death. They may be due to failure of the respiratory centre, but more commonly result from atelectasis. Pulmonary collapse is common and very fatal during the first two or three days. It is rare after the tenth day. The alveoli in the lungs may not be fully expanded at birth; the respiratory centre is not educated fully and the ribs are very soft. The more premature the infant, the greater is the liability to cyanosis, especially during the first few days of life. The longer the child lives, the less severe are the attacks and the less likely are they to be fatal. Cyanosis is a bad, but not necessarily a fatal symptom. It is sometimes due to food getting into the trachea, and can be remedied by inverting the child and patting its back.

Sudden death is often due to cardiac failure, and may be quite unexpected.

General œdema is common in the premature. It may be due to a feeble heart, imperfect action of the kidneys, or to anæmia. The tendency to anæmia is great, on account of the usual destruction of red corpuscles and the delayed development of hæmoglobin formation. Uric acid is secreted in abundance. It forms fan-shaped infarctions in the kidneys and stains the napkins pink. Nasal catarrh and bronchitis are serious complications, and so, too, is any form of gastro-enteritis. Granted the conditions are favourable, the prognosis is not hopeless in even the minutest babes. In the case of twins it is by no means uncommon for the smaller to be the only survivor. The most favourable conditions are two skilled nurses, an incubator, a physician who understands such cases, and parents who do not interfere and press for changes of treatment.

Gavage.—This is the name given to the method of forced feeding by the passage of a tube into the stomach and the insertion of food through it. The necessary apparatus consists of a soft rubber tube, twelve inches long, about the size of a No. 14 French catheter, and a small glass funnel fitted into the larger end of the tube. In order to pass it into the stomach, the child is held in a horizontal or half-reclining position, on the operator's lap, with the head a little raised. The mouth is opened by gentle pressure on the chin, and the tongue can be depressed, if necessary, by the left forefinger. The end of the tube is wetted with human milk, warm water, or a little oil, and held between the finger and thumb. It is introduced through the mouth

as far back as the base of the tongue, or pressed gently against the posterior wall of the pharynx. Reflex acts of deglutition are set up, and the tube passes onward without effort into the stomach, a distance of about six inches. Milk freshly drawn from the breast, or food suitably mixed and warmed, is poured into the funnel and allowed to pass slowly into the stomach, the tube being compressed between the finger and thumb to regulate the flow. Care must be taken not to give too much at a time and not to give it too quickly. When removing the tube it must be compressed and withdrawn rapidly or, if taken out slowly, all the introduced food will be vomited.

This method of feeding is suitable for all children who for any reason are unable to swallow. In some children, notably those with any throat affection, the tube should be passed through the nose. It may be used for feeding premature children. It is suitable in the presence of persistent vomiting. It is a curious fact that food introduced in this manner can often be retained, even in large quantity, although food taken in the ordinary manner is at once vomited. A possible explanation is that the prolonged and repeated irritation of the vagus and sympathetic nerves, induced by the acts of swallowing, are avoided, and also the repeated mechanical stimulation of the stomach by the entrance of small quantities of food at each act of swallowing. The number and quantity of the feeds depend, as in other circumstances, on the weight, age, and strength of the infant. The same evils result from over-feeding as if the child were fed from the bottle. Special care must be taken to keep the tube and funnel clean.

Statistics from the Paris Maternité show the influence of gavage and use of the incubator on the mortality of premature infants :

TABLE CXVI.

Influence of Forced Feeding and the Use of the Incubator on Mortality.

Duration of gestation.	Percentage mortality. Formerly.	Recently.
6 months	100·0	84·0
6½ "	78·5	63·4
7 "	61·0	50·2
7½ "	46·0	23·0
8 "	22·0	11·2
8½ "	12·0	4·0

Lavage.—Washing out the stomach is sometimes of great value in the feeding of nursing infants. It is carried out by the introduction of a tube, after the method described in the last paragraph, then pouring in the fluid used for the washing, and withdrawing it by syphon action. Allow any gas present in the stomach to escape before pouring in the water.

The solution used may be simple warm water, or a solution of bicarbonate of soda in distilled water. From one-half to one ounce may be poured in at a time, and then withdrawn and the process repeated three or four times until the water returns clear. Lumps of curd may be disintegrated by repeated washing, or may be vomited up by the side of the tube together with tenacious masses of mucus. After the washing let the child remain perfectly quiet for half an hour before nursing or feeding. If artificial food is given, let it be bland and easily

digestible, such as egg-albumin water or diluted peptonised milk, for the next twenty-four hours.

Lavage may be employed for repeated vomiting, poisoning, convulsions due to indigestible food, and occasionally under other conditions. Prostration and urgent thirst may be relieved by leaving an ounce of water in the stomach after the washing. The process is not unattended with danger, and may cause sudden death from syncope, or give rise to convulsions. Poisonous antiseptics must not be used.

CHAPTER XIX.

THE GROWTH OF INFANTS AND CHILDREN.

There is no feature in the management of infant feeding which exceeds in importance the regular weighing of the child once or twice a week. In hospital practice it is of very great value, and, in my opinion, is greatly conducive to proper maternal care. By its means the physician can almost certainly tell whether his directions have been accurately carried out. Other factors being normal, the loss of weight indicates that something is wrong with the diet. Moreover, the mother appreciates much more clearly the importance of carrying out directions accurately, and that the scales will betray her if she neglects the child. Very often she is keenly anxious to know whether it is gaining weight and delighted when it goes on well.

The increase in weight of children is the best indication of satisfactory progress. The absence of the normal weekly gain in weight indicates some deficiency in the quantity or the quality of the food, or the presence of some disturbing factor, such as teething or the onset of some morbid process. Very often a loss of weight is the only indication that anything is wrong with the child, and may be

regarded as a kind of danger-signal. Similarly the presence of an increase of weight, although the child does not seem to be going on quite satisfactorily, is usually enough to show that there is nothing serious amiss.

Increase in weight is not always an absolutely reliable sign of perfect health; there should be also a progressive increase in height. Thus, a rachitic infant may put on fat to a considerable extent, especially when fed on condensed milk and patent foods, and yet be the very reverse of strong and healthy.

An absence of increase in weight, as shown by the weekly weighing, is frequently the only sign that a hand-fed baby is not getting a sufficient quantity of food or a sufficiently nutritious food. This applies both to healthy infants and to those under treatment for various disorders. In the latter case there is much too great a tendency to ascribe the lack of gain in weight to the constitutional disturbance rather than to the food-supply. The explanation is often right. A loss of weight is a more valuable sign of something amiss than the presence of a gain is a sign that all is well. In hospital practice it is not very uncommon to find a marked increase in weight in a child recently admitted, although it may be suffering from a serious disorder. This gain is due to the better quality of the food, the greater regularity of feeding, the warmth and cleanliness, and the better nursing. The progressive increase rarely continues for more than a week. Sometimes we see marked increase in weight due to the development of œdema.

Whenever a loss of weight is noticed, and to a

certain extent the same holds good in the case of the absence of a gain, care and attention must be devoted to finding out the cause. Among some of the common causes may be mentioned teething, insufficient or innutritious or unsuitable food, cold weather and insufficient clothing, and simple morbid processes, such as dyspepsia and infantile diarrhœa. Most of these can be remedied as soon as the weekly weighing shows that one or other is in operation. Without the weighing there might be no indication of anything wrong. If none of these causes accounts for the loss, some more serious morbid process, such as the onset of a specific fever or the presence of deep-seated tuberculous mischief, may be the source of the loss.

Method of Weighing.—A useful apparatus is Hawksley's Infant Weighing Machine, consisting of an elongated basket tray supported on a recording dial and weighing up to twenty-eight pounds, by ounces. A better one is made by Messrs. Avery and weighs up to twenty pounds, in quarter-ounces. A more expensive machine is used in France, the weight being estimated by the metric system. A good pair of kitchen scales will suffice, but it is very common to find that such scales are not accurate.

The child should be weighed at exactly the same time on successive days during the first month of life, and after that once a week up to the end of the first year of life. The most suitable day to select for the weekly weighing is Sunday, as it is less likely to be forgotten than a week-day. The child should be weighed after being washed and wrapped in a warm flannel. The weight of the flannel must be

taken and subtracted from the total weight, and the result recorded on the chart provided.

It is advisable to make use of suitable charts, such as are here illustrated,* one for the first month of life and one for the first year. A record of the weight, number of the feeds, the amount of food taken in the twenty-four hours, and the number of stools passed, should be kept. Room on the chart should be left for the insertion of notes as to the nature and composition of the food. Supposing the amount of food taken to remain the same, the increase in weight will be greater if the bowels have not acted than when they have been freely open. The weight of the daily excreta during the first month may be taken at from 20–30 grammes ($\frac{3}{4}$–1 ounce).

The weight of a child at birth varies considerably; 3000 grammes, or six and a half pounds, may be taken as a fair average, but this is often exceeded. Boys are generally heavier than girls. The children of primiparæ are usually smaller than those of multiparæ and, as a rule, the child of younger primipara weighs less than that of an older one. Such rules are not of much practical value, as the size of the child depends mainly on the physical health and build of the mother; the surrounding circumstances of the mother as to food-supply, rest, and freedom from worry; and the period of gestation at which the child is born.

During the first three days of life there is usually a decided loss of weight on account of the passage of meconium and urine; partly also due to loss of

* These charts may be obtained separately from the publishers, Messrs. J. & A. Churchill, 7 Great Marlborough Street, W.

water from the skin and lungs; and largely due to the lack of food to supply nutriment to replace the waste. The drying up and separation of the funis accounts for a loss of 20–40 grammes. The total loss of weight from these combined causes varies in amount from five to ten per cent. of the original weight, and it is often not regained until the end of the second week of life. Most variable results are met with. Thus, in a boy, second child, the loss of weight was 8 ounces in two days, but he weighed 19 ounces more than at birth at the end of the second week. The total loss has been estimated by Haake, Quetelet, and Winckel at 222 grains, about half a pound. To a certain extent the loss may be regarded as physiological, but it does not always take place, some infants gaining from birth. The child of a primipara is more likely to lose a greater percentage of its original weight and to recover the loss with greater slowness than the child of a multipara. This is simply due to the fact that the milk-supply of the primipara is not as quickly established. The prolonged presence of colostrum corpuscles in the milk, from nervous disturbance or other cause affecting the mother, will induce a loss of weight in an infant who would otherwise gain steadily. Colostrum corpuscles disappear from the milk of multiparæ more rapidly than from that of primiparæ.

The gain in weight may be remarkably regular and steady. More often it occurs by fits and starts, especially during cold weather or at the time of the eruption of a tooth. Periods of retardation are usually followed by periods of acceleration, both in the breast-fed and the hand-fed infants. At a dental period there is a minimal gain or even an actual loss.

Speaking generally, the initial weight is doubled in five months and trebled in twelve to fifteen months. Such results are often exceeded. Thus a breast-fed infant of $7\frac{1}{2}$ pounds doubled its weight in 13 weeks; and a bottle-fed baby of 9 pounds weighed 25 pounds at six months of age. Bottle-fed babies do not usually increase as rapidly as the breast-fed; but it entirely depends on the mode of feeding. If the food is suitable in quantity and quality the bottle-fed child may gain even more rapidly than the breast-fed, especially in the case of the child of a primipara whose milk-supply is somewhat scanty.

Rotch gives the following figures as applying generally. They are based on an original weight of 3500 grammes (7·7 pounds) and a gain of 30 grammes (one ounce) per day for the first four months, and 10 grammes per day for the last eight months of the first year.

TABLE CXVII.

General Figures of Weight (ROTCH).

Age.	Weight.		Average gain per day.	
	Grammes.	Pounds.	Grammes.	Ounces.
At birth	3000–4000	6·6–8·8	—	—
From birth to 5 months		—	20–30	$\frac{2}{3}$–1
From 5 to 12 months		—	10–20	$\frac{1}{3}$–$\frac{2}{3}$

TABLE CXVIII.

The Rate of Gain in Weight (ROTCH).

Age.	Weight.	
	Grammes.	Pounds.
At 1 year	9,500	20·90
At 7 years	19,000	41·80
At 14 years	38,000	83·60

In Table CXX. Schmid-Monnard gives the weight, length, and circumference of the head and chest of children during the first thirty months of life. The figures were obtained from 3000 children, and each average is based on 600–800 measurements. The children were healthy and from Halle and Frankfort-on-the-Maine.

Hähner's investigations gave the following results showing the daily and monthly increase in weight:

TABLE CXIX.

Rate of Increase in Weight (HÄHNER).

Age.	Weight in Grammes.	Monthly increase.	Rate per day.
		grammes.	grammes.
At birth . .	3100	—	—
1 month . .	3835	735	24·5
2 months . .	4930	1095	36·5
3 " . .	5540	610	20·3
4 " . .	6010	470	15·6
5 " . .	6680	670	22·3
6 " . .	7005	325	10·8
7 " . .	7680	675	22·5
8 " . .	8100	420	14·0
9 " . .	8370	270	9·0
10 " . .	8680	310	10·3
11 " . .	9170	490	16·3
12 " . .	9470	300	10·0

TABLE

The Growth of

BOYS.					
Age in months.	Weight.	Gain.	Length.	Chest.	Head.
0	—	—	—	31·6	34·1
1	3451	—	50·6	31·8	34·8
2	4108	657	54·1	35·0	37·4
3	4840	732	55·6	36·6	38·8
4	5670	830	59·9	39·0	40·2
5	5868	198	60·5	37·7	41·2
6	6802	934	63·0	40·3	42·3
7	7017	215	64·4	40·2	42·8
8	7152	135	66·1	42·3	43·4
9	7579	427	67·4	41·5	44·5
10	8312	733	65·9	42·2	44·5
11	8412	100	69·6	42·6	44·7
12	8588	176	71·0	43·2	45·7
13	8479	−109	70·7	43·0	45·4
14	8897	418	72·2	43·7	46·2
15	8825	−72	73·0	43·7	46·2
16	9414	589	74·1	44·0	46·7
17	9810	396	76·0	45·0	46·5
18	9650	−160	74·6	45·0	46·9
19	9818	168	76·1	45·2	47·2
20	9973	155	77·5	46·1	46·9
21	9911	−62	75·7	44·9	46·6
22	10334	423	78·2	45·4	48·3
23	10329	−5	78·1	45·0	47·9
24	10547	218	78·8	45·5	48·0
25	10542	−5	80·0	46·9	47·8
26	11130	588	81 6	47·1	48·6
27	11100	−30	80·0	47·2	48·5
28	11000	−100	82·0	46·0	49·0
29	11150	150	82·5	46·3	48·3
30	11407	257	83·7	47·1	48·9

CXX.

Infants (SCHMID-MONNARD).

GIRLS.				
Weight.	Gain.	Length.	Chest.	Head.
—	—	—	31·1	33·1
3219	—	50·1	31·4	33·6
4002	783	53·8	34·5	36·2
4792	790	57·5	36·2	37·3
5409	617	59·3	37·5	39·1
5866	457	61·0	38·8	40·0
6426	560	62·2	38·9	41·2
6855	429	64·0	39·8	42·1
6936	81	64·9	39·8	42·7
7396	460	66·9	40·4	43·2
7527	131	67·0	41·0	43·9
7588	61	67·0	41·0	43·9
7756	168	68·1	41·1	44·4
8277	521	71·8	42·3	44·8
8350	73	70·9	42·3	45·1
8200	− 150	70·5	42·3	45·2
8807	607	72·5	43·3	45·9
9164	357	73·8	43·6	46·3
9219	55	74·1	44·2	45·4
9247	28	73·8	44·1	46·0
9084	− 163	74·6	43·5	45·7
9261	177	75·2	43·3	46·0
9887	626	77·7	45·2	46·3
9700	− 187	77·0	45·1	46·4
10106	406	79·5	45·5	46·5
10058	− 48	79·2	45·0	46·5
10336	278	80·4	45·9	46·9
10508	172	80·0	45·7	46·7
10150	− 358	80·0	44·8	47·1
11100	950	83·5	46·1	47·7
10829	− 271	83·4	47·1	46·8

Sutils in the Archives of Pediatrics, 1890, gives somewhat similar figures.

TABLE CXXI.

Rate of Increase in Weight (SUTILS).

Age.	Weight in grammes.	Monthly increase.	Rate per day,
		grammes.	grammes.
At birth . .	3000	—	—
1 month . .	3750	750	25·0
2 months . .	4450	700	23·3
3 " . .	5100	650	21·6
4 " . .	5700	600	20·0
5 " . .	6250	550	18·3
6 " . .	6750	500	16 6
7 " . .	7200	450	15·0
8 " . .	7600	400	13·3
9 " . .	8000	400	13·3
10 " . .	8350	350	11·6
11 " . .	8700	350	11·6
12 " . .	9000	300	11·0

From the above tables and other data we can deduce a fair average of the rate of growth during the first year of life. For this purpose it is simpler to divide the year into thirteen months of twenty-eight days each. The figures represent ounces.

TABLE CXXII.

The Rate of Increase in Weight during the First Year.

	Daily.	Weekly.	Monthly.
First month	$\frac{6}{7}$	6	24
Second "	1	7	28
Third "	$\frac{6}{7}$	6	24
Fourth "	$\frac{11}{14}$	$5\frac{1}{2}$	22
Fifth "	$\frac{5}{7}$	5	20
Sixth "	$\frac{9}{14}$	$4\frac{1}{2}$	18
Seventh "	$\frac{4}{7}$	4	16
Eighth "	$\frac{7}{14}$	$3\frac{1}{2}$	14
Ninth "	$\frac{5}{14}$	$2\frac{1}{2}$	10
Tenth "	$\frac{5}{14}$	$2\frac{1}{2}$	10
Eleventh "	$\frac{2}{7}$	2	8
Twelfth "	$\frac{2}{7}$	2	8
Thirteenth "	$\frac{3}{14}$	$1\frac{1}{2}$	6

Roughly, this amounts to a gain of six ounces a week during the first three months, five ounces a week for the second three months, three ounces for the third three months, and two ounces a week for the remainder of the year. The increase in weight does not take place with such absolute regularity, as indicated in the table, either in bottle-fed or breast-fed infants. To a certain extent the rate of gain is affected by the period of the year, attaining its maximum between July and Octcber. Sunlight is also beneficial to increased growth, just as in the vegetable world. Fresh air is of importance as an accelerating agent.

The rate of gain is usually proportionate to the initial weight of the infant, but this rule does not invariably hold good. Sometimes infants abnormally small at birth gain weight with much greater rapidity than those of a much larger initial weight. Sometimes infants will increase steadily in weight from the time of birth to the end of the first year, or even longer, and more commonly is this the case with the breast-fed than with the bottle-fed. This is due to the greater liability to digestive disturbance from the latter mode of feeding, with the resulting attack of intestinal or digestive disturbance.

Apart from this danger there is no reason why a hand-fed child should not increase in weight with a regularity as great as, or even greater than, the breast-fed. The amount and quality of its food can be so easily regulated.

Escherich gives the following table of the life-history of a hand-fed infant during the first year of its life:

TABLE CXXIII.

The Diet and Increase in Weight of a Hand-fed Infant.

Month.	Week.	Food in grammes.			No. of meals daily.	Amount of each meal.	Weight of child.	Gain.
		Milk.	Water.	Total.				
I.	½	150	250	400	8	50	3275	− 225
	1	200	200	400	8	50	3275	+ 0
	2	250	250	500	8	62	3376	+ 101
	3	300	200	500	8	62	3477	101
	4	350	250	600	8	75	3579	102
II.	5–6	400	400	800	7	115	3942	per week
	7–8	450	450	900	7	128	4306	182
III.	9–10	500	400	900	7	128	4614	154
	11–12	550	450	1000	7	143	4921	
IV.	13–14	600	400		7	143	5259	164
	15–16	650	350		7	143	5576	
V.	17–18	700	300		6	166	5848	136
	19–20	750	250		6		6119	
VI.	21–24	800	200		6		6679	140
VII.	25–28	900	100		6		7234	139
VIII.	29–32	1000	none		6		7669	108
IX.	33–36	1200		1200	6	200	8089	105
X.	37–40	1200	plus		6		8391	76
XI.	41–44	1200	other		6		8662	72
XII.	45–48	1200	food.		6		8893	58

The table indicates the amount of food which can be taken by an infant, but it is doubtful whether it is advisable to give quite such large quantities for each feed during the first two months or to give the milk so little diluted, and even undiluted, during the later months.

A fairly typical life history of a baby brought up by hand may be given as illustrative of some of the points above referred to. It is not an example of the most perfect method of feeding an infant on artificial food.

TABLE CXXIV.

Life History of a Hand-fed Baby for One Year.

Date.	Age.	Weight.	Weekly gain in ounces.	Diet and Remarks.
1891				
Dec. 22	At birth.	7 lb. 0 oz.	—	Breast-fed.
1892				
Jan. 22	4 weeks.	7 ,, 5 ,,	5	,,
,, 29	5 ,,	7 ,, 8 ,,	3	Weaned.
Feb. 5	6 ,,	7 ,, 13 ,,	5	Hand-fed, *vide infra.*
,, 12	7 ,,	7 ,, 13 ,,	0	Very cold weather. Changed to all woollen clothing.
,, 19	8 ,,	8 ,, 4 ,,	7	
,, 26	9 ,,	8 ,, 15 ,,	11	Rubbed with cod-liver oil from the second
Mar. 4	10 ,,	9 ,, 5 ,,	6	to the sixth month.
,, 11	11 ,,	9 ,, 5 ,,	0	
,, 18	12 ,,	10 ,, 0 ,,	11	Gain of 6 oz. weekly
,, 25	13 ,,	10 ,, 8 ,,	8	during February and March.
April 1	14 ,,	11 ,, 0 ,,	8	Gain of 8 oz. weekly
,, 22	4 months.	12 ,, 8 ,,	8	during April, May, and June.
June 22	6 ,,	16 ,, 9 ,,	8	Still more rapid gain
July 22	7 ,,	18 ,, 2 ,,	6	during August.
Aug. 22	8 ,,	21 ,, 3 ,,	12	Delayed by gastro-enteritis during October and November.
Dec. 22	12 ,,	23 ,, 0 ,,	—	Length, 2 ft. 6 in.

From February 5 to March 22, the diet consisted of seven feeds daily. Each feed was composed of:

Boiled milk	1 ounce
Cream	$\frac{1}{2}$,,
Milk sugar	1 drachm
Water	$1\frac{1}{2}$ ounces = Total of 3 ounces

From the age of three to six months each feed was composed of:

Boiled milk	. . .	2¼ ounces
Cream .	. . . .	½ ounce
Milk sugar .	. . .	1 drachm
Water .	. . . .	1¼ ounces = Total of 4 ounces

At seven months the amount of milk was increased, the amount of cream unaltered, and a teaspoonful of Mellin's food given twice a day. When nine months old an attack of gastro-enteritis occurred, probably due to the artificial food. At the age of ten months the child took two pints of milk daily and Savory and Moore's food in each bottle. Gastro-enteritis ensued during October and November and was probably due to over-feeding with too rich food. Mellin's food was tried on two subsequent occasions and each time gave rise to some diarrhœa.

The weight of this child was doubled in five months and trebled in eight months. Periods of delayed growth were followed by periods of much accelerated growth—*e.g.* the eighth, ninth and twelfth weeks. The influence of cold was very marked in the seventh week and was easily remedied by the change to woollen clothing. The average monthly rate of growth during the year was one pound two and a half ounces, or a weekly gain of four and a quarter ounces. This average would have been very much higher if digestive disturbance had not occurred in the later months of the year and if it were calculated from the time of weaning. Thus, from January 22 to August 22, the weight increased no less than fourteen pounds all but two ounces, or an average gain per calendar month of almost two pounds, or a weekly gain of seven ounces.

Sometimes breast-fed children increase even more rapidly in weight. The eight-month old child of a

German woman of the lower class came under my care for whooping cough. It was a fine healthy looking child with a good colour and not a trace of rickets about it, except the absence of teeth. The mother was of medium height and build, and said the child was not particularly big at birth. She had had three other children, one of which had died of croup and one of water on the brain; also two miscarriages, so the maternal history cannot be considered very favourable to the child. The latter had been brought up entirely on the breast for the first six months, and for the last two had been given in addition various mouthfuls of extra food such as coffee, milk and cocoa. Its flesh was firm and the fontanelle small, and it weighed twenty-three and a half pounds. Its age was a few days under eight months. As a contrast to this a hand-fed babe under my care, on a home-modified milk mixture, weighed 25 lbs. at the age of six months and had two teeth.

Growth in Length.—The average length of the new-born male child is twenty inches and the female about half an inch less. Needless to say the size varies considerably according to the weight of the child, the degree of development and the duration of gestation. The rate of increase in length has been determined by Liharzik to follow a definite law, in an arithmetical series, thus:

Month.	First.	Third.	Sixth.	Tenth.	Fifteenth.	Twenty-first.
a.	a + b.	a + 2b.	a + 3b.	a + 4b.	a + 5b.	a + 6b.

A series in arithmetical progression where a = 50 cm. or 20 inches; b = 7½ cm. or 3 inches.

This series gives a more rapid rate of growth than is found to occur on reference to Schmid-

Monnard's table. According to that table the average rate of growth is about three quarters of an inch (2 cm.) per month during the first year. These figures, being deduced from the average results of measurements of a large number of children of a given age, are not conclusive, but in actual practice are more constant than those of Liharzik's scheme. Growth in length takes place most rapidly during the early months of the year from March up to the end of June, and is not so rapid in the winter months. A period of rapid growth in length is often accompanied by delay in increase of weight, and preceded by a rapid increase in weight. The two processes rarely take place at the same time. The body appears to store up material preparatory to increase in growth, this being indicated by the increase in weight.

APPENDIX A.

THE PREPARATION OF FOODS SUITABLE FOR INFANTS AND CHILDREN.

Albumin Water.—Take the white of a fresh egg and cut it in various directions with a clean pair of scissors. Shake it up in a flask with a pinch of salt and six ounces of pure cold water. Strain through muslin. It may be more diluted and sweetened with sugar or flavoured, if desired. It may be given alone or mixed with milk, fresh or condensed. It is a useful method of giving proteid to infants who digest the milk proteids badly, and as a temporary food in various conditions.

Alkaline Solution.—Buy bicarbonate of soda (baking powder) in packets of one drachm each, and add one such packet to a pint and a half of distilled or pure boiled water. Shake well and keep in a tightly corked bottle. This makes a solution of the strength of a grain to a tablespoonful. It may be used instead of lime water.

Arrowroot Food.—Mix milk, cream, lime water and arrowroot water in equal parts. Add one teaspoonful of sugar to eight ounces of the mixture. This amount is suitable for an infant about nine months of age.

Arrowroot Gruel.—Rub up two teaspoonfuls of arrowroot with a little cold water into a smooth paste and pour on it, while stirring, half a pint of boiling water. It may be boiled for three minutes to render it more digestible. Flavour with sugar and spices if desired.

Arrowroot Pudding.—Mix up a tablespoonful of arrowroot with cold water into a paste and pour on it while stirring, a pint of boiling milk; add one egg, well beaten with a tablespoonful of white sugar. Boil for five to ten minutes.

Arrowroot Water.—Rub up a teaspoonful of arrowroot with a tablespoonful of cold water until smooth; pour on it, while stirring, a pint of boiling water and boil for five minutes.

It may be used as a diluent for milk in cases of diarrhœa.

Baked Flour.—Spread a thin layer of flour in a flat tin tray and place it in a hot oven for three hours, or heat it to 212° F. for five or six days. Barley flour is the best, but either wheat or oatmeal may be used. A small portion of the flour is converted into dextrine. It may be given in cases where starchy foods are permissible and possesses a little advantage over ordinary flour.

Barley Jelly.—Add a pint and a half of water to two heaping tablespoonfuls of washed pearl barley and boil slowly down to a pint. Strain out the barley and let the liquid settle to a jelly.

Two teaspoonfuls in warm sweetened milk, eight ounces, are enough for a feed for a child nine months of age.

Barley Water.—This is an almost pure solution of starch and may be made according to one of the following methods:

1. Grind up two teaspoonfuls of dry clean grain barley in a coffee-mill. Place it in a jug and pour on it, while stirring, a pint of boiling water. Stand the jug near the fire for an hour, stirring occasionally, and then strain through muslin. Add a pinch of salt.

2. Thick: make in the same way but with only half the quantity of water and boil for fifteen to twenty minutes.

3. Put two teaspoonfuls of prepared barley into a clean

enamelled saucepan and add a little water; boil rapidly for five minutes and throw the water away. Then add a pint of cold filtered water and boil slowly down to two-thirds of a pint; strain through muslin.

4. Bartholow's Method: Wash two ounces of pearl barley with cold water; boil it for five minutes in fresh water and throw both waters away. Then pour on two quarts of boiling water and boil it down to one quart. Strain and flavour with thin lemon peel and sugar.

5. Boil four ounces of barley flour in one quart of water for half an hour and strain.

6. Wash a tablespoonful of pearl barley in cold water. Strain off the water and pour on the barley a quart of boiling water and add the rind of a lemon, peeled thin, and two or three lumps of sugar. Let it stand for seven or eight hours and strain.

Barley Water and Egg.—*Vide* Egg and Barley Water.

Beef Essence.—1. Mince up a pound of rump steak, without fat, and place it in a mortar with three tablespoonfuls of water; pound it well and put it aside to soak for two hours. Then put it, with a pinch of salt, in a covered earthen jar; cement the edges of the cover with dough and tie a piece of cloth over the top. Place the jar in a pot half full of boiling water and let it simmer on the fire for four hours. Strain through a coarse sieve. (Starr.)

2. Mince up lean beef into small pieces and put them into a wide-mouthed bottle securely corked. Stand the bottle for several hours in boiling water and strain.

3. Mince up half a pound of fresh beef and add to it half a pint of pure cold water, an eggspoonful of salt and five drops of pure hydrochloric acid. Mix well and, after standing an hour, pass it through a conical sieve without pressure, refiltering until the fluid runs clear. Next pour a second half-pint of water on the residue and allow it to filter through. Mix the two filtrates.

Dose: One teaspoonful to one tablespoonful, according to age.

Beef Juice.—1. Take a piece of fresh raw beef and scrape it well with a fork or meat scraper, or mince it finely; place it in the bottom of a cup, and just cover with pure cold water to which a pinch of salt has been added. Let it stand for an hour and squeeze through muslin.

2. Chop up lean beef and add it to cold water in the proportion of two ounces to one. Stand it in a covered jar in ice for six to twelve hours; squeeze through coarse muslin. Give it warm or cold. Flavour with salt, celery salt or sherry. It can be made stronger by using less water.

3. Cut up some lean rump steak or sirloin of beef into pieces which will go into the cavity of a lemon-squeezer, or use a proper meat press. Broil rapidly before the fire; heat the squeezer by dipping it in hot water and forcibly express the juice through it. Season with salt and give warm. One pound of steak will yield two to three ounces of juice.

The first method gives the best results. The juice may be given warm or cold. To warm it put the vessel containing it in hot water. If too great a heat is applied the albumin is coagulated and the value of the juice much diminished. It may be given alone, or mixed up in milk in the bottle, in doses of a teaspoonful to a tablespoonful, according to the age of the child.

Beef Pulp.—Take a piece of raw lean rump steak or undercut of sirloin of beef and scrape it thoroughly, so as to separate the muscle fibres from the tendinous parts. Discard the latter and pound up the remainder in a mortar into a pulp; then rub through a hair sieve and season with a little salt and pepper.

A teaspoonful may be given three times a day to an infant under one year, rubbed up with water to the consistency of a thick cream. For older children it may be

rolled up into small balls and lightly fried or grilled. Or it may be given spread between thin layers of bread and butter. This is a very nutritious and digestible food.

There is a slight danger in the use of raw meat preparations and beef tea made without exposure to a moderate temperature. This risk is the introduction of the cysticercus of one of the tape worms. The danger is small and far counterbalanced by the amount of good some of these preparations accomplish, especially the raw meat pulp and meat juice. They keep very badly in hot weather.

Beef Tea.—Numerous methods are in vogue of which the following are some of the best. No beef tea is nearly as nutritious as it is commonly thought to be. The usual preparations contain very little proteid matter and are chiefly solutions of gelatin, extractives and salts. They are stimulant but not nutritious. If heated to boiling-point the small amount of proteid, which has passed into solution, is coagulated and is generally strained off, although it is the most nutritious part of the food. The first mode of preparation gives the best results in nutritive products. No beef tea is as valuable a food as beef juice, nor as the beef essence made according to the third mode described, and it should be regarded rather as a stimulant than a food.

The same remarks apply to most of the meat extracts in the market, such as Liebig's, Brand's, Armour's, Mason's, &c. Bovril is of rather greater value. So, too, the meat juices, such as Valentine's, Wyeth's, &c., contain little nutriment. There is no advantage in using these proprietary foods, except perhaps for the sake of saving trouble or while on a journey. Fresh meat can be obtained very easily, and not only is the nutritive value of the juice and pulp prepared from it greater than that of the proprietary foods, but also the expense is considerably less.

1. Mince one pound of lean beef and add to it one pint of pure cold water and ten drops of dilute hydrochloric acid.

Let it stand for two or three hours, with occasional stirring, and then simmer for ten or twenty minutes.

2. Mince up half a pound of lean fresh raw rump steak and put it with a pint of cold water into a clean covered tin saucepan. Stand it by the side of the fire for four hours and then simmer gently for two hours. Skim thoroughly to remove the grease. Do not let it boil.

3. Mince finely one pound of lean beef and put it with its juice into an earthen vessel containing a pint of water at a temperature of 75° C., and let it stand for an hour. Strain through muslin, taking care to squeeze all the juice out of the meat. Then heat slowly on the fire just to boiling-point; remove and flavour with salt.

When given, stir up the sediment; it consists of coagulated albumin and is very nutritious, the most valuable part of the preparation.

4. *Rapid Method.* Scrape one pound of lean meat with a fork or meat scraper and put it into a clean enamelled saucepan; pour on it half a pint of boiling water and, after putting the cover on the pan, stand it on the hob for ten minutes. Then strain it into a cup and put the cup in ice water. When cold, skim thoroughly. Season and warm it when required for use.

Beef Tea and Oatmeal.—Mix up a teaspoonful of oatmeal with cold water into a thin paste and pour on it, while stirring, a pint of hot beef tea. Boil for ten minutes, with frequent stirring, and strain through a coarse sieve. Add salt and spices to taste. Suitable for older children.

Biedert's Cream Mixture.—*Vide* p. 168.

Blanc-mange.—Whip up three ounces of white sugar with a pint of cream and enough lemon extract to flavour; add the mixture to a solution of half an ounce of gelatin in half a pint of water. Make the mixture while warm and heat it to a moderate stiffness; then pour into moulds.

Milk may be used instead of water to make it still more nutritious.

The common kind of blanc-mange is a cornflour jelly or mould, *vide infra.*

Bread Jelly.—Take four ounces of stale crumb of bread and break it into small pieces; cover with boiling water and let it stand for six hours. Squeeze out the water and add fresh water to the pulp. Boil for an hour and a half; squeeze out the water and pass the pulp through a fine hair sieve. On cooling a jelly is formed.

It may be given with sweetened milk or with plain water, in the proportion of a tablespoonful to eight ounces. If mixed with plain water only it is very deficient in proteid and fat; these may be added in the form of raw meat juice and cream. It must be prepared fresh twice daily, as it will not keep.

Broths.—*General Formula.*—Add one pound of minced meat to one pint of cold water; stand it for four or five hours. Cook slowly over the fire for an hour, evaporating it down to half a pint. Cool, skim off fat, and strain. It will contain about one per cent of proteid.

1. *American.*—Put alternate layers of finely minced meat and vegetables in a tin vessel which can be hermetically sealed. Seal it up and keep it in a hot-water bath for six or seven hours; then press out the broth.

2. *Paris Hospital Broth.*—Mix up two pounds of minced meat, one pound of fresh vegetables, and two teaspoonfuls of salt; boil the mixture very slowly over a gentle fire for six hours. Strain and press out the juice.

3. *Chicken.*—Take a small chicken and remove from it the skin and fat; chop it up, bones and all, into small pieces; add a little salt, and place the whole in a covered saucepan with a quart of hot water. Simmer gently for two hours and, after allowing it to stand for another hour, strain it through a sieve.

4. *Mutton.*—Mince up a pound of lean mutton and put it into a saucepan with three pints of water; add a little salt and allow it to simmer gently for two hours. Then strain into a basin, finally squeezing the residue in a coarse cloth. Skim off the fat when cold. Serve hot.

5. *Veal.*—Mince up a pound of lean veal and pour on it a pint of cold water. Let it stand for three hours and then slowly heat to boiling-point. Strain through a fine sieve and add a little salt.

None of these broths possess much nutritive value and, like beef tea, are chiefly extracts containing gelatin, salts, and extractives. A more nutritious fluid can be made by digesting the meat in the cold with the aid of dilute hydrochloric acid, as in the first method described for making beef tea. Any kind of broth can be thickened by the addition of one of the farinaceous foods, such as cornflour, rice or pearl barley.

Caraway Water.—Put one ounce of caraway seeds in a small muslin bag and boil it in a pint of water, until reduced to half a pint.

It may be given alone or in the bottle, hot or cold, for flatulence and colic. Other spiced waters may be made in a similar way.

Caudle.—Beat up an egg to a froth; add a glass of sherry and half a pint of gruel. Flavour with lemon peel, nutmeg, and sugar.

Useful for older children in debilitated conditions.

Chavasse's Milk Food.—Mix equal parts of new milk and water, each at a temperature of 90° F.; add a small pinch of salt and enough sugar to slightly sweeten the mixture.

Eight to twelve tablespoonfuls may be given to a child from three to nine months of age. It is digestible but deficient in fat.

Cheadle's Food.—Mix four parts of bread jelly, made with water only, three parts of raw meat juice, half a pint of cream, and one-fifth part of sugar. The meat juice and the bread jelly must be quite fresh and made twice daily. It is a highly nutritious food.

Chicken Broth.—*Vide* BROTH.

Clear Soup.—Cut a shin of beef into small pieces and put it into a saucepan with just enough water to cover it. As soon as it boils, skim it and add a bundle of sweet herbs, a little turnip, carrot, and celery, and a little pepper and salt. Add more water and let the whole boil for three hours; then strain and put it on one side until the next day. Skim off all the fat, add browning to taste, and heat it again. Beat up two eggs to a froth and put them into the soup with a whisk. Let it boil gently for ten minutes and then strain through a cloth.

Consommé.—Mince up a pound of lean beef and put it into a saucepan with three pints of water. Boil down to one pint, frequently skimming, and strain. Mince up half a pound of lean beef and mix it well with three raw eggs; beat up this mixture with the broth and boil for half an hour.

Cornflour Jelly.—Mix up one teaspoonful of cornflour into a thin paste with a little cold water in a tumbler, and pour on sufficient boiling water, while stirring, to form a clear jelly. Add a little sugar.

Cornflour Mould.—Put one pint of milk into a milk saucepan or clean enamelled pan and bring it to a boil; add a pinch of salt. Mix up a quarter of an ounce of cornflour into a thin paste with a little cold water and stir it into the milk when almost boiling. Boil gently for ten to twenty minutes.

For infants under one year of age use equal parts of milk and water.

Cream and Whey.—Mix an ounce of cream, two ounces

of whey, two ounces of hot water, and one teaspoonful of milk sugar or cane sugar. Prepare the whey according to the first method. (*Vide* WHEY.)

It is suitable for infants who digest casein badly.

Effervescing Milk Punch.—*Vide under* PEPTONISED FOODS.

Egg-Albumin.—*Vide* ALBUMIN WATER.

Egg and Barley Water.—Put the white of one fresh egg in a saucer and cut it in various directions with clean scissors. Shake it up in a flask with six ounces of thin barley water and strain through muslin. Add a teaspoonful of white sugar.

The addition of an ounce of cream will render it a more perfect food. It may be given warm from the bottle but must not be boiled.

Egg-Milk.—A fluid resembling human milk in the proportions of proteid, fat, and carbohydrate, can be made by mixing egg-albumin, cream, and white sugar in suitable amounts.

Mix six ounces of albumin water, one and a half ounces of cream, and a half-ounce of sugar. The mixture contains about 2 per cent. of proteid, 4 of fat, and 6·4 of sugar.

Egg-nog.—Scald some new milk by putting it in a jug into a saucepan of boiling water, but do not let it boil. Beat up a fresh egg with a fork in a tumbler with some white sugar; add a dessertspoonful of brandy, and fill up the tumbler with the scalded milk when cold.

This is a very nutritious drink for older children in acute disease.

Egg and Brandy.—Rub up the yolks of two eggs with a tablespoonful of white sugar, and add four tablespoonfuls of brandy, and eight of cinnamon water. Dose, one teaspoonful to one tablespoonful every two hours.

Eiloart's Mixture.—Make two ounces of meal from

wheat, barley, or oats, into gruel with a pint and a half of water in the inner vessel of a double boiler. Take out the inner vessel and add twenty-six ounces of cold water and then a teaspoonful of malt extract. Let it stand for fifteen minutes. Put back the inner vessel, heat for fifteen minutes, and strain through wire gauze. Give with milk.

The starch is converted into dextrin and maltose, and little insoluble starch remains. If, as in the presence of diarrhœa, less maltose is required, let the mixture stand for only three minutes after the addition of the cold water and the malt extract; then boil for ten minutes to stop further conversion.

Entire Wheat-meal Cakes.—To two pounds of coarsely ground or crushed whole wheat meal, add half a pound of fine flour or medium fine Scotch oatmeal and a sufficient quantity of baking powder and salt. When well mixed, rub in about two ounces of butter and make into a dough with half milk and half water, with skimmed milk, or with all milk if preferred. Make into flat cakes, like tea cakes, and bake without delay in a quick oven, leaving them afterwards to finish at a lower temperature.

Flour Ball.—Take one pound of good wheat flour, unbolted if obtainable, and tie it up very tightly in a strong pudding cloth. Put it in a saucepan and boil constantly for ten hours. When cold, remove the cloth and cut away the soft outer covering of dough that has formed and reduce the hard-baked interior by grating. In the yellowish white powder obtained almost all the starch has been converted into dextrin by the cooking. (According to Leeds this conversion does not take place. He boiled wheat flour in a bag for five days, fifteen hours a day, and found on analysis almost identically the same percentages of soluble and insoluble carbohydrates in the flour before

and after the boiling. The food must, therefore, be regarded as pure starch.)

Frankland's Artificial Human Milk.—Allow one third of a pint of milk to stand for twelve hours; remove the cream and mix it with two-fifths of a pint of perfectly fresh cow's milk. Take the milk from which the cream has been removed and put a piece of rennet, about an inch square, or a little fluid rennet, into it. Keep the vessel containing it in a warm place until the milk is fully curdled, about five to fifteen minutes, according to the activity of the rennet. If solid rennet is used, it may be removed as soon as the curdling commences and kept for future use. Break up the curd completely and carefully separate the whole of the whey, which should then be rapidly heated to boiling-point to destroy the remaining ferment. Then strain through muslin and dissolve 110 grains of powdered milk sugar in the hot whey. Mix the whole with the two-thirds of a pint of new milk to which the cream from the other fluid was originally added. The artificial mixture is now ready for use and must be given within twelve hours of its preparation. It contains about half the proteid of ordinary cow's milk.

Gelatin.—Soak a piece of plate gelatin, two inches square, in cold water for three hours and then dissolve with stirring, in half a pint of boiling water. On cooling it forms a jelly.

Or, place a piece of plate gelatin, one inch square, in half a tumblerful of cold water and let it stand for three hours; turn the whole into a teacup, place this in a saucepan half full of water, and boil until the gelatin is dissolved.

One or two teaspoonfuls may be added to each bottle of milk food, and is said to prevent the formation of large coherent curds.

Gelatin Food.—Prepare gelatin in the same way as

above, and while it is hot stir in a teaspoonful of arrowroot, previously rubbed up into a thin paste with cold water. Add milk and cream in varying proportions.

Gelatin and Milk.—Dissolve a tablespoonful of gelatin in half a pint of hot barley water; add two tablespoonfuls of powdered sugar and stir in one pint of milk.

Gravy Soup.—Heat one pint of gravy, beef tea, or mutton broth and, when almost boiling, stir in half an ounce of cornflour, barley meal, ground rice, oatmeal, semolina, or wheat meal, made into a thin paste with cold water. Boil for ten minutes.

Gruel.—*Vide* ARROWROOT, OATMEAL, &c.

Gum Arabic Water.—Dissolve a large tablespoonful of gum arabic in a pint of boiling water, and sweeten with a little sugar. Sometimes used as a diluent instead of barley water.

Hominy Grits.—Boil two tablespoonfuls of hominy until quite soft, and then rub up with butter until quite light; add slowly half a pint of boiling milk, with constant stirring. Strain through a sieve and boil for ten minutes. Flavour with sugar or salt, and serve.

Imperial Drink.—Pour a pint of boiling water on a large teaspoonful of cream of tartar, a little sugar, and a few pieces of lemon peel. Strain when cold. It is cooling and diuretic.

Jelly.—*Vide* ARROWROOT, BARLEY, BREAD, CALVES' FOOT, CORNFLOUR, OATMEAL, RAW MEAT, SAGO, TAPIOCA.

Chicken Jelly.—Clean a fowl, about a year old, and remove the skin and fat. Chop it up, bones and all, and put in a saucepan with two quarts of water. Let it simmer for five or six hours, skimming often and carefully. Add salt and spices to taste and put on one side

to cool. When cold skim off the fat. Give in small quantities often, hot or cold.

Fruit Jellies.—Such as red or black currant and crab apple jelly.

Port Wine Jelly.—Put one ounce of isinglass into a quarter of a pint of water and set it on the fire until it is dissolved. Then add one ounce of sugar and a pint of port wine. Strain through muslin into a mould and allow it to set.

Junket.—Heat a pint of milk to a temperature at which it can just be comfortably sipped, and add, with gentle stirring, two teaspoonfuls of wine of pepsin or Fairchild's essence of pepsin. Or one of the preparations of rennet may be used for the purpose. Let it stand until firmly curdled and serve with sugar, nutmeg, or cream.

Junket and Egg.—Beat two eggs to a froth with a tablespoonful of white sugar and add to the mixture a pint of milk. Curdle with pepsin or rennet.

Lait de Poule.—Beat up the yolks of two eggs with hot water into an emulsion; sweeten with sugar, and flavour with a little orange-flower water.

Lemonade.—1. Pare the rind off a lemon thinly and cut the lemon into slices. Put both into a jug with one ounce of white sugar and pour over them a pint of boiling water. Cover the jug closely and strain when cold.

2. Rub two or three lumps of sugar on the rind of a lemon; cut it in half and squeeze out the juice; pour on it three-quarters of a pint of cold or iced water or a bottle of soda water.

3. *Effervescing.*—Make the lemonade with cold or iced water as above; put it in a large tumbler and add half a small teaspoonful of bicarbonate of soda or potash.

Lime Water.—Put a piece of unslaked lime as large as a walnut into two quarts of cold, boiled, filtered water in

an earthen vessel; stir it up thoroughly and allow it to settle. Keep covered. Pour off the clear solution from the top as required for use. Pour in more water when necessary, and stir.

Lime Water (*Saccharated*).—Mix up, by rubbing in a mortar, one ounce of slaked lime and two ounces of powdered white sugar. Put this in a quart bottle with a pint of distilled, or boiled and filtered water; cork, and shake occasionally for a few hours. Then let it settle, and pour off the clear solution into a glass stoppered bottle.

It may be added to the baby's bottle in doses of five to fifteen drops.

Linseed Tea.—Add to a pint of water two tablespoonfuls of linseed, a quarter of an ounce of bruised liquorice root or a piece of liquorice as big as a filbert, and sugar candy to taste. Boil for half an hour and strain.

Meat Extracts and Meat Juices.—*Vide* BEEF JUICE and BEEF TEA.

Meat Powder.—Mince cold boiled beef finely and dry in a water bath or a slow oven; grind it to powder in a coffee mill. Brand's Nutrient Powder is of this nature.

It may be given in milk, cocoa, broths, &c., in doses of a teaspoonful to a tablespoonful three times a day. Plasmon, the casein of milk precipitated by acetic acid and dried, may be used instead. It is cheap and easily obtained.

Meat Punch.—Take two tablespoonfuls of the powdered meat, three of syrup of punch, and sufficient milk to make a very fluid mixture.

This is a nutritious and stimulating food in debilitated conditions.

Milk Preparations:

Biedert's Cream Mixture.—*Vide* p. 168.

Chavasse's Milk Food.—*Vide* CHAVASSE.

Meig's Milk Mixture.—*Vide* MILK SUGAR FOOD.

Rotch's Milk Mixture.—*Vide* pp. 163, 169, 172.

Milk and Cinnamon.—Add to half a pint of boiled milk one teaspoonful of milk sugar and one of brandy, and sufficient powdered cinnamon to flavour. It is useful in diarrhœa, and may be given warm or cold.

Milk and Egg Albumin.—Shake up together for five minutes the whites of three eggs and three tablespoonfuls of lime water. Add one pint of cool milk, previously boiled, with constant stirring for ten minutes. Keep in a cool place.

It is a nutritious food for older children.

Milk and Gelatin.—*Vide* GELATIN.

Milk and Oatmeal.—Stir up one teaspoonful of fine oatmeal into two tablespoonfuls of hot water, until thoroughly mixed; then add five tablespoonfuls of milk, one of cream, and a teaspoonsful of milk sugar or cane sugar; mix well.

Suitable for a child of four or more months with constipation; may be given a little diluted to a younger child.

Milk Foods (Proprietary).—Plasmon is the dried casein of milk after it has been precipitated by acetic acid. Protene, Nutrose and Eucasin are somewhat similar. They are sometimes useful, but rarely necessary.

Milk Punch.—*Vide under* PEPTONISED FOODS.

Milk Sugar Food.—Milk one ounce, cream two ounces, lime water two ounces, and milk sugar solution three ounces. The milk sugar solution is made by dissolving seventeen teaspoonfuls of milk sugar in a pint of hot water. This is recommended as a food for infants, from birth to the age of nine months, by A. V. Meigs.

Mutton Broth.—*Vide* BROTH.

Oatmeal Gruel.—Mix a tablespoonful of oatmeal with two of cold water; add this to a pint of boiling water in a

saucepan, stirring constantly. Boil and stir for ten minutes. Flavour with sugar or salt.

Oatmeal Jelly.—Soak two ounces of coarse oatmeal in a quart of cold water for twelve hours. Boil down to one pint and strain through fine muslin while hot. A jelly forms on cooling. Warm for use and add a little salt.

Oatmeal Porridge.—Add half a teaspoonful of salt to a pint of boiling water in a saucepan, and sprinkle in three or four ounces of oatmeal, until sufficiently thick, keeping it constantly stirred with a porridge stick. Boil gently for fifteen minutes; add a little more boiling water and boil for another five minutes.

It may be served with milk, cream, sugar, treacle, salt, &c.

Oatmeal Porridge and Milk.—Put a pint of milk into an enamelled saucepan, and, when nearly boiling, stir in three or four ounces of oatmeal. Boil for twenty minutes and serve as desired.

Oatmeal Soup.—Make a thin paste of two ounces of oatmeal with cold water and stir it into a pint of hot broth. Pour it through a fine strainer into a saucepan, and boil for ten minutes.

Oatmeal Water.—1. Put a large tablespoonful of oatmeal porridge into a quart of cool water and heat, with constant stirring, to boiling-point. Strain.

2. Or it may be made by pouring half a pint of boiling water, with stirring, on to a large teaspoonful of oatmeal in a jug; add a pinch of salt and stand it by the fire for an hour, with occasional stirring, and then strain.

3. Stir one tablespoonful of fine oatmeal into one pint of boiling water; cover and let it simmer for an hour. Replace the water as it evaporates. Strain.

It may be used as a diluent, instead of barley water or plain water, if the child suffers from constipation.

Oyster Soup.—Drain a pint of oysters through a

colander to remove the fluid and then pour over them a pint of boiling water, which must be thrown away. Mix a pint of water and half a pint of fresh milk and boil; stir into the boiling fluid a tablespoonful of cornflour, made into a thin paste with cold water, a little butter, salt and pepper; boil for ten minutes, and, just before serving, turn in the oysters and heat for another three minutes.

Peptonised Foods.

Humanised Milk.—Add one measure (supplied with the tin) of Fairchild's Peptogenic Milk Powder to two ounces of milk, two ounces of water, and half an ounce of cream; mix well. Put the whole in a nursing bottle in hot water, at about 120° F., for five minutes. Let it cool a little and it is ready for use.

Peptonised Beef Tea.—Mince up half a pound of lean raw beef and add one pint of cold water; cook over a slow fire, with constant stirring, until it has boiled for a few minutes. Strain off the fluid and rub up the meat in a mortar to a paste. Put the latter in a jar with half a pint of cold water and add the fluid previously obtained. Then add thirty grains of extract of pancreas and twenty grains of bicarbonate of soda; mix thoroughly and keep at 110° F. for three hours, stirring frequently. Finally, boil quickly, strain, and serve as required.

Peptonised Lean Meat.—Add four ounces of minced raw meat to half a pint of water and gradually bring to a boil. Then add half a pint of cold water so as to reduce the temperature to about 140° F. and add thirty grains of *zymine* and twenty grains of sodium bicarbonate. Keep warm for three hours and the meat will be peptonised. Fairchild's zymine powders may be used, and the addition of the alkali is then not requisite, being already mixed in the powder.

Meat Peptones.—Various preparations are in the market, containing large quantities of peptones, or peptones and albumoses mixed. Of these somatose is the most valuable, containing about 80 per cent. of digested proteids. It is odourless and tasteless. Next in order of merit come Liebig's Peptone and Darby's Fluid Meat. Other preparations are Denaeyer's Peptone, Brand's Peptone, Fairchild's Panopepton, &c. They are unpleasant to take, unless mixed up with other foods such as broths, &c., and their use is of only temporary value. The continued use of peptonised foods weakens the digestive functions. Albumoses often set up diarrhœa.

Peptonised Milk.—1. Pour one pint of milk and a quarter of a pint of water into a clean quart bottle; add one tube of Fairchild's zymine powder, and shake up well. Put the bottle into water as hot as the hand can bear, and keep it there for five to twenty minutes. Boil for three minutes, to stop further digestion, and keep in ice. The boiling is not essential, if the milk can be kept surrounded with ice. The process should be stopped as soon as the milk tastes the least bitter, or before, according to the amount of peptonisation desired.

2. *Complete Peptonisation.*—Mix as in the above method, but let the bottle stay in the hot water for two hours; then boil for a few minutes to destroy the ferment.

Peptonised milk is rather bitter, and can be made more palatable by the addition of sugar and some spice such as nutmeg. Wine of pepsin, Benger's peptonising powders or liquor pancreaticus, or Fairchild's peptogenic milk powder or zymine, may be used to carry out the conversion of the proteids. Fairchild's zymine is supplied in glass tubes, each containing five grains of pancreatic extract and fifteen grains of bicarbonate of soda, sufficient to peptonise one pint of milk.

Peptonised Milk Mixture for Infants.—Mix an

ounce and a half of cream, two and a half ounces of peptonised milk, four ounces of pure water and two teaspoonfuls of milk sugar or cane sugar. Boil for a few minutes. Cool down and give.

Peptonised Milk Gruel.—Mix thoroughly one large teaspoonful of arrowroot or wheat flour with half a pint of water, and heat, with constant stirring, until it has boiled for three minutes. Add one pint of cold milk and stir in one tube of zymine. Let the mixtures stand in a vessel, surrounded by hot water at 120° F., for half an hour. Pour into a clean bottle and surround with ice until wanted. Serve warm.

Peptonised Milk Punch.—Fill a tumbler one-third full of ice; add one to four teaspoonfuls of rum and sugar to taste. Then fill up with peptonised milk, made according to the first method. Stir up, add a little nutmeg, and strain.

Peptonised Effervescing Milk Punch.—Fill a tumbler one-third with ice, squeeze in the juice of one-half a lemon and add two teaspoonfuls of sugar. Fill the glass with equal parts of Apollinaris water and peptonised milk, made by the second method.

Other foods may be peptonised, partially or completely, in somewhat similar ways. They are not often required. The peptogenic milk powder contains extract of pancreas, soda, and other alkalies, and milk sugar in proportions devised for mixing with definite amounts of cream, milk, and water to prepare a suitable food for an infant.

Raw Meat Emulsion.—Take two ounces of the pulp of beef, half an ounce of blanched sweet almonds, half a bitter almond, and half an ounce of white sugar. Pound them up together in a mortar and add enough water to make an emulsion.

Raw Meat Jelly.—Mix two ounces of the pulp of lean

meat, made by scraping, fifteen grains of salt, and one pound of fruit jelly of any kind.

Raw Meat Juice.—*Vide* BEEF JUICE.

Raw Meat with Milk and Sugar.—Scrape out the pulp from half a pound of raw rumpsteak, pound up with sugar and add enough milk to make the mixture of the thickness of arrowroot. Strain through a gravy strainer. A little brandy may be added, if required.

Raw Meat Soup.—Mince up one pound of raw beef and place it in a bottle with one pint of water and five drops of strong hydrochloric acid. Stand the mixture in ice all night, and in the morning set it in a pan of water at 110° F., for two hours. Strain through a stout cloth, squeezing the residue so as to obtain all the juice. If the taste of the raw meat is much disliked, fry or grill quickly the beef on one side and then proceed as before.

It may be given in three portions during the day for a child of eight to twelve years of age. It does not keep well.

Rice Milk.—Wash well one ounce of rice in cold water and drain off the water; soak it in fresh water for twelve hours and drain. Add the soaked rice to a pint of boiling milk, with half a teaspoonful of salt and of sugar. Stir well and boil for an hour. Rub through a hair sieve.

Rice Paste.—Put four tablespoonfuls of well washed rice into three pints of water and boil for half an hour. Set it aside in the back of the range to simmer during the day, water being constantly added to make up the three pints. At night strain through a colander and place on ice. When cold, a paste is formed.

It may be given in amounts up to three tablespoonfuls in eight ounces of milk. It is useful in cases of diarrhœa.

Rice Pudding.—Soak two ounces of rice for twelve hours; add the soaked rice to a pint of boiling milk and stir until it thickens. Take off the fire and mix well into

it two ounces of butter, a little grated nutmeg or lemon peel, and sugar. Cool and bake in a well buttered dish.

Rice Pudding with Egg.—Take three ounces of rice and swell it gently in one pint of new milk. Let it cool and stir well into it one ounce of fresh butter, two ounces of powdered sugar, the yolks of three eggs and some grated lemon peel. Pour into a well buttered dish and put on the top the whites of three eggs beaten up with three tablespoonfuls of powdered sugar. Bake for twenty minutes until lightly browned.

Rice Soup.—Soak half an ounce of rice for ten hours; drain off the water and stir the rice into a pint of boiling stock. Simmer in a partially covered saucepan for two hours. Season with salt and add the yolks of two eggs.

Rice Water.—Take a large tablespoonful of well washed rice and macerate it for two hours in a quart of water kept at a tepid heat; then boil slowly for an hour and strain. It may be flavoured with lemon peel, nutmeg, or other spice.

Often useful as a diluent of milk in cases of diarrhœa.

Sago.—Put half an ounce of sago into an enamelled saucepan with three quarters of a pint of cold water and boil gently for an hour and a quarter. Stir frequently and skim when necessary. Add a dessertspoonful of white sugar.

Sago Jelly.—Soak two tablespoonfuls of sago, carefully washed, in half a pint of cold water for four hours. Then add half a pint of hot water, a pinch of salt, a tablespoonful of sugar, and a little grated lemon peel; boil gently for fifteen minutes, frequently stirring. A little sherry or port wine may be added before removing from the fire. It may be served hot or cold.

Sago Milk.—Prepared in the same way as rice milk.

Sago Soup.—Stir two tablespoonfuls of well washed sago into a pint of boiling meat broth or stock in a sauce-

pan; put on the cover and let it simmer until quite soft. Skim and serve hot.

Soda Solution.—*Vide* Alkaline Solution.

Soups.—*Vide* under the headings of the kind desired.

Tapioca.—Wash two tablespoonfuls of the best tapioca, soak in cold water over night. Drain off the water, add a little salt, a pint of milk or water, and simmer until quite soft. Pour into a bowl and stir in a tablespoonful of white sugar while cooling.

Tapioca Jelly.—Soak a cupful of tapioca with a pint of cold water and put it, when soft, into a clean enamelled saucepan with some sugar, the rind and juice of one lemon, a little salt and another pint of water. Stir until it boils; then pour into a mould and let it cool.

Tapioca Pudding.—Beat up the yolks of two eggs with a tablespoonful of white sugar and stir it into a pint of tapioca, made with milk as described above. Pour into a pie-dish and bake in a slow oven.

Tapioca Soup.—Stir three quarters of an ounce of washed tapioca into a pint of boiling meat broth or stock in a saucepan; put on the cover and let it simmer until the tapioca is quite soft. Skim and serve.

Toast Water.—Pour a pint of boiling water on to two or three well toasted slices of bread; let it stand until cool and then strain.

A useful drink in fevers or in vomiting.

Treacle Posset.—Add a pint of boiling milk to two or three tablespoonfuls of treacle or golden syrup. Boil it well and strain. Serve hot.

Suitable for a child who has got wet or cold; best given at bedtime.

Veal Broth.—*Vide* Broth.

Veal Tea.—Cut into small pieces a pound of veal, free

from fat, and put it into a pint and a half of cold water. Simmer gently for three or four hours. Strain, cool and skim off the fat. Serve hot.

Whey.—Heat half a pint of fresh milk to about 140° F. and add one teaspoonful of Prime Bristol Rennet, or Fairchild's Essence of Pepsin, and stir just enough to mix. Stand it in a warm place until firm curdling results. Beat up the curd with a fork until finely divided and then strain. (*Vide* also p. 271.)

By squeezing the curd through a coarse cheese cloth a good deal of fat and finely divided casein pass through, and the fluid is rendered much more nutritious.

Whey and Cream.—*Vide* Cream and Whey.

Whey and Cream of Tartar.—Mix a large teaspoonful of cream of tartar with two tablespoonfuls of hot water and add it to a pint of boiling milk. Add a little sugar and lemon peel and strain when cold.

Whey and Lemon.—Boil a pint of milk with two teaspoonfuls of lemon juice and when curdled, strain through muslin, squeezing the residue.

Wine Whey.—1. Add one to two ounces of sherry to half a pint of milk, while boiling. Strain, sweeten, and serve. The curd may be well mashed up and squeezed through a cloth to make the fluid more nutritious. To make it clear stand it until the curd settles.

2. Or boil three wineglassfuls of milk and add one of sherry or port. Strain, and add one wineglassful of water.

It may be given in doses of one to four tablespoonfuls three times a day. Teaspoonful doses may be given to infants under one year of age.

APPENDIX B.

DIRECTIONS SUITABLE FOR THE MOTHERS OF HOSPITAL OUT-PATIENTS.

The following directions are inserted to illustrate the composition of a simple and convenient pamphlet containing instructions for the mothers of infants. Mothers usually have sufficient sense and intelligence to carry them out, and can obtain the food recommended. I have found that most infants are able to digest the quantities recommended and thrive well on the mixtures, but some require a richer food. The only defect is the deficiency of fat; hospital patients cannot obtain cream, so it is useless to recommend it further than is done in the pamphlet. The statements are necessarily dogmatic.

BELGRAVE HOSPITAL FOR CHILDREN.

DIRECTIONS TO MOTHERS

Respecting the Feeding of Infants and Children.

The best food for an infant until it reaches the age of nine months is the mother's milk. No preparation of cow's milk, whether fresh or condensed, is nearly as good. Patent foods are decidedly injurious, and should never be given before the age of nine months, except on the advice of the doctor. Whenever possible, the babe should be suckled until it reaches this age.

Breast-Feeding.—On no account is the child to be put to the breast whenever it cries. It must be given the breast only at regular intervals, and if asleep when the time for feeding comes round it must be awakened. If it wakes and cries during the night, or in the intervals between the feeds, a teaspoonful or two of hot water may be given. Such crying is usually due to indigestion or colic and is relieved by anything hot. Breast milk will relieve it for a few moments only, and then the child will be worse than ever. Care must be taken to give the breast slowly; too rapid sucking is likely to cause vomiting or indigestion. Each feeding must extend over 15–20 minutes by the clock.

During the **First Month** the breast must be given at these times: 5.0, 7.0, 9.0, and 11.0 o'clock in the morning; 1.0, 3.0, 5.0, 7.0, 9.0, and 11.0 o'clock in the afternoon and evening.

During the **Second Month** the child must be fed every two and a half hours: at 5.0, 7.30, and 10.0 in the morning; 12.30, 3.0, 5.30, 8.0, and 10.30 in the afternoon and evening.

After the Age of Two Months the child must only be fed every three hours: at 5.0, 8.0, and 11.0 in the morning; 2.0, 5.0, 8.0, and 11.0 in the afternoon and evening.

The mother must begin to wean the child when it is nine months of age and, except on medical advice to the contrary, the child must be completely weaned at the end of another month. It is not true that a woman will not have another child as long as she is suckling. Long continued suckling is bad for both mother and child.

If, from having to go out to work or from not having enough milk or from any other cause, the mother is unable to bring the child up entirely on the breast, a milk mixture, such as is recommended under the head of artificial

feeding, must be given in the place of the omitted breast-feed, and at the corresponding time. Remember that in all cases breast milk is of more value to the child than the corresponding artificial mixture. Never assume that the mother's milk disagrees with the child, and do not put the child on any form of condensed milk or patent food, except on medical advice.

Artificial Feeding.—The best kind of bottle is the boat-shaped one, with a simple india-rubber nipple on the end. A bottle of this kind is much easier to keep clean than one with a long tube. All rubber tubes must be avoided, because the milk sticks to the inside of them and is likely to go bad, especially in hot weather, and to set up diarrhœa. The use of the boat-shaped bottle takes up a little more time and trouble; the mother must hold the bottle on the slope, so as to keep the teat always full, and thus prevent the child swallowing a lot of air. Each feed must be given very slowly. Any milk over must not be kept for the next feed, as it is very likely to go bad. Wash the bottle and teat in hot water and soda after each feed, and rinse out in clean cold water.

The milk should be got from a large dairy company twice a day; such milk is almost always of good and constant quality. Do not be persuaded to get the milk from one special cow, as the quality varies much more than the mixed milk of a large number of cows.

The child's stomach is *very* small, so be careful not to give too much food at a time.

Feeding during the **First Month.**—The bottle must be given every two hours from 5.0 in the morning to 11.0 at night. Each feed must consist of :

	1st Week.	2nd Week.	3rd Week.	4th Week.
Boiled cow's milk .	2 teasp'nf'ls	3 teasp'nf'ls	4 teasp'nf'ls	5 teasp'nf'ls
Cream . .	1 "	1 "	1 "	1 "
Boiled water .	5 "	6 "	7 "	8 "
Sugar . .	1 small lump	1 lump	1 lump	1 lump
Lime water .	1 teasp'nf'l	1 teasp'nf'l	1 teasp'nf'l	1 teasp'nf'l

The lime water must not be boiled, but must be added when the milk and water have cooled down. Each feed must be given warm, but not hot. In cases where cream is not given, the child must have half a teaspoonful of cod-liver oil twice a day.

During the **Second Month**, the bottle must be given every two and a half hours, from five in the morning to 10.30 at night, namely, at 5.0, 7.30, 10.0, 12.30, 3.0, 5.30, 8.0, 10.30. Each feed must consist of:

Boiled cow's milk . .	2 tablespoonfuls
Boiled water . . .	2 "
Cream	1 teaspoonful
Sugar	1 small lump
Lime water . . .	3 teaspoonfuls

After the end of the Second Month, the child must only be fed every three hours—at 5.0, 8.0, and 11.0 in the morning, and 2.0, 5.0, 8.0, and 11.0 in the afternoon and evening. Between the ages of **two and six months**, each feed must consist of:

Boiled cow's milk . .	3 to 4 tablespoonfuls
Barley water . . .	3 to 4 "
Sugar	1 lump

Cream in the amount of one to four teaspoonfuls can be added to each feed, with great benefit to the child. If not, cod-liver oil must be given.

From the age of **six to nine months**, each feed must consist of :

Boiled cow's milk . .	5 to 6 tablespoonfuls
Barley water . . .	5 to 6 ,,
Sugar	1 lump

with the addition of cream, if possible, in the same amount as advised for younger infants. If not, cod-liver oil must be given.

If the child is sick when taking the above diet, bring it to the hospital.

Weaning.—This must take place gradually; the process should occupy three or four weeks. During the **first** week, the child must have **one** feed of milk and barley water, prepared in the same way as for infants six to nine months of age, and given at eight o'clock in the morning, **instead of the breast.** During the **second** week, the child must have **two** such feeds daily, at eight in the morning and eight at night.

During the Third Week.		During the Fourth Week.	
5.0 A.M. . . .	Breast	5.0 A.M. . . .	Breast
8.0 ,, . . .	Milk	8.0 ,, . . .	Milk
11.0 ,, . . .	,,	11.0 ,, . . .	,,
2.0 P.M. . . .	Breast	2.0 P.M. . . .	,,
5.0 ,, . . .	Milk	5.0 ,, . . .	,,
8.0 ,, . . .	Breast	8.0 ,, . . .	,,
11.0 ,, . . .	Milk	11.0 ,, . . .	,,

After the age of ten months the child may have an increased amount of milk, or a little bread and milk, bread and butter, and custard or tapioca pudding; or, to begin with, a teaspoonful or two of cornflour in its milk.

Between the ages of twelve and eighteen months the child should have five meals in the day, which should be made up as follows: At **6 a.m.**, a glass of milk and a plain biscuit; at **8 a.m.**, breakfast, consisting of bread and milk,

or porridge and milk; at **noon**, dinner, consisting of mashed potato and gravy, breadcrumb and gravy or broth, milk pudding, egg custard, and milk and barley water; at **4 p.m.**, tea, made up of bread and butter, the yolk of a softly boiled egg, or bread and milk; at **bedtime**, give a glass of milk and a biscuit.

After eighteen months, in addition to the above diet, give in the middle of the day, undercooked mince and finely chopped greens, or plain boiled fish and potatoes. At tea time, a little cocoa may be added to the milk.

Give all meals at fixed hours, and do not allow eating between meals. See that the child eats slowly.

Do not give the child beer, cheese, pickles, fruit, nuts, pastry, cakes, or sweets.

To make Barley Water.—Put a teaspoonful of well-crushed barley, or of prepared barley, in a jug, and pour on it half a pint of boiling water, add a pinch of salt, and stand it by the fire for an hour, stirring frequently; then strain through muslin. Make it fresh twice a day.

Raw Meat Juice.—Scrape about a quarter of a pound of raw beef well with a fork, and put it in a cup; just cover it with water, to which a pinch of salt has been added. Let it stand for an hour, and then squeeze through fine muslin. A teaspoonful may be given with advantage to any infant, alone or with milk. It must be made fresh.

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